PB-228 799

UNIVERSITY CURRICULA IN RADIOLOGICAL HEALTH

Public Health Service
Washington, D.C.

1974

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PB 228 799

University Curricula in Radiological Health

Symposium
held at
Princeton, N.J.
Aug. 2-4, 1960

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**U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE**

PUBLIC HEALTH SERVICE
Division of Radiological Health
Washington 25, D.C.

Statement of Purpose

In March 1959, the National Advisory Committee on Radiation submitted a written report to the Surgeon General, U.S. Public Health Service, which stated:

"From studies made by this Committee, it appears that the following constitute the personnel needs of the United States in the field of radiation control through the year 1970:

(a) radiation health specialists -- 1,200
(b) radiological specialists -- 4,000

"These estimates are based upon the belief that approximately three to four technicians will be required for each health specialist in a nominal control program and that approximately one radiation health specialist will be needed for each 200,000 of population when the atomic energy industry approaches full development. Future studies may, of course, alter these values.

"It is anticipated that the demand for radiation health specialists will increase progressively as State and local control programs develop. At the present time, the Public Health Service and State and local health agencies have need for 150 specialists who have completed a full program of training in radiation protection. By the end of 1960, it is anticipated that these needs will have expanded to the point where 650 individuals can be profitably utilized; by 1970, it is estimated that 1,200 will be required. These figures are over and above those currently needed by the Atomic Energy Commission for the conduct of its safety programs."

Since the report was issued, graduate and undergraduate programs covering various aspects of radiological health are now being offered in a number of schools of medicine, public health, and engineering. Certain universities have already gained much experience in this area. The experience of other universities is of more recent origin, while still other interested institutions of learning are only just entering the planning stages.

Because the activities and the planning of nearly all schools are still in a comparatively early stage, there has to develop a general consensus respecting overall qualification standards for specialists in radiological health as well as the educational requirements most suitable for this attainment.

With this in mind, the Division of Radiological Health of the U.S. Public Health Service sponsored a 3-day symposium August 2-4, 1960, at Princeton University, on the subject of university curricula in radiological health. Representatives of universities, professional societies, governmental health agencies, and others with a principal interest in this field were invited to attend. This was done in the hope that such occasion would provide an opportunity for a productive interchange of ideas between experts active in this field.

This report of the symposium was excerpted from a transcript of the proceedings, and approved or edited by the participants.

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The Outlook

Introduction and Welcome

Dr. Francis J. Weber, Chairman: One of the responsibilities of the Division of Radiological Health of the U. S. Public Health Service, required of us by law and, perhaps of more importance, expected of a national program in any health field by the general public is to assess the needs.

In examining this new, and to all of us, exciting field of radiological health, one of the most important steps is to assess professional and public understanding, which are equally important and in a certain sense mutually interdependent.

In the hearings before the Congress during the past few years, a number of questions recurred over and over again. One was, "Why don't we move faster in developing activities in certain areas?" and another was, "Why have we not done better in advancing public understanding?"

I think it is quite natural in considering this type of questioning, to conclude that the universities have an extremely important role in both of these phases, as well as in many others. It seems also that to achieve more widespread understanding of the problem and the applications based on this understanding in the field, the present symposium is a very necessary first step.

Radiological health is the newest problem area to appear in the broad health picture; it is one which still remains to be evaluated, both in terms of the positive contributions of ionizing sources and the safety requirements to insure that these beneficial contributions can be made without undue hazard.

Educational institutions are only beginning to develop formal, organized academic training in these health aspects. It is nearly always true that a full appreciation of health effects is slow to appear in recently advanced technology and certainly this field appears to be a prime example of that fact.

In saying this, I want to say also that the role of each one of us, regardless of discipline, centers about the contribution that each can make to the protection of human health. Being myself a physician who has come to have a nodding acquaintance, at least, with certain special aspects of this field, I sometimes have to explain to my fellow physicians that although the subject is called "Radiological Health," and even though the physician has the decisive role in judging whether a clinical condition is the result of radiation exposure or the result of something else, there are many other professions in this complicated field whose work will have primacy at various stages of the whole complex. One has only to consider the list of participants in this symposium for proof.

We depend on the health physicist to inform us on the details of physical exposure, for example. And we physicians sometimes have to remind ourselves that Konrad Roentgen, the discoverer of a primary medical tool, was himself a physicist, not a physician.

We depend on the radiochemist to tell us what is in the radioactive materials presenting potential or actual health hazards, as well as something about the complicated interactions of ionizing agents and living tissue.

From the radiobiologist and others in the biological sciences, we seek further enlightenment on the ways in which tissue physiology may be affected by ionizing radiation and the significance of these changes for the whole organism in relation to various body disorders.

We depend upon the geneticist for the refined details of how the genetic apparatus may be unfavorably altered as well as judgments necessary for a projection of effects on new generations.

We rely on the engineer for practical applications from the physical and chemical sciences which take the form of better engineering devices and their uses, as well as the proper way to manage the radiation in our environment.

Indeed, there is no scientific discipline within my knowledge which is not involved in one way or another in this new field, even to the political scientists and economists who concern themselves with the broad questions of the uses of these powerful energy sources as working tools of our society.

It seems, therefore, that one of the tasks facing this assembly is to determine how we can develop a common core of knowledge among all professions and segments of society. To do that involves, among other things, the establishment of some common idiom.

The Sponsor's Role

As sponsor of this symposium, we in the Division of Radiological Health believe that we are carrying out the intent of the executive branch of the Federal government, supported by the President and, more immediately, the Surgeon General, both of whom, and others as well, of course, are aware of the importance of the field. We are expected to work with competent groups such as yours in our efforts to reach the goal of optimum health for all our citizens. The Surgeon General is directed by law to cooperate with institutions and private groups in the advancement of programs of mutual interest.

Over the years, a well organized national-State-local health complex has been developed to attack a particular public health problem of which radiation is the most recent example. What we see in this complex is not national dominance nor State dominance nor local dominance but rather, an operation based on an overall consensus. Nor is any program fixed to operate in a certain way for all time. On the contrary, each one is subject to continuous review and necessary revisions are made from time to time.

We believe that the effort initiated here will follow these historic lines of procedure. Hence this is but the beginning of a process which can be expected to continue until the educational aspects of the program you are considering will have that uniformity and flexibility appropriate for this particular field.

An increase in our funds during the present year, accompanied by many requests and expressions of interest, is enabling general support for this symposium. Here we are given an opportunity to define the practical needs as those of us present see them, so that your expert educational knowledge may be better applied to advancing the national program. We would like to feel that we are providing a setting whereby educators can meet and attain general agreement as to what types of education are needed in the field of radiological health. We hope to gain an idea of what can be done. We hope to identify the institutions which can conduct the type of training most desirable for work in industry, hospitals and other institutions, as well as governmental agencies.

Our own study of training needs, ably delineated by special studies like that of our special advisory committee, has set forth certain specifics respecting the need for workers in this field. We expect that the results of these studies will again be recounted here.

What is already a well-recognized fact is the urgent requirement for adequately trained persons in quantity and with special capabilities, prepared for general radiation protection operations in the rapidly growing areas of application.

Within the Federal government this is not confined by any means to the Public Health Service, but is also a requirement of the Atomic Energy Commission (whose responsibility was expanded recently to implement Public Law 86-373), the Department of Defense, and other governmental agencies. In addition, States and local communities need a large number of workers because of the increase in radiation sources and their applications on the local scene. The need for trained research workers is, of course, obvious. A large number will be required eventually for the teaching of others. We hope, therefore, that you will give particular attention to the types of training providing at least minimum preparation for these important fields.

Universities are already receiving support for radiological health in its various phases from different sources, governmental as well as private. It is quite obvious, however, that the level of support must rise if we are to keep pace with the expansion of nuclear applications, and the attendant need for competent professionals trained at national, regional, and local educational centers.

Speaking again for the Public Health Service, general support for training workers in research through grants administered by the National Institutes of Health has assisted radiological health training. However, more training has taken place in closely related fields than in radiation research per se. Title I of the Training Act, a general public health traineeship program, has made a small addition to the number of workers in the field.

The director of this program, Dr. Elmer Hill, is present to explain it and the techniques employed to attain its objective. This is of some practical importance because the possibility exists for special categorical funds for radiological health training.

In that connection there are two legislative support proposals pending:

1. Support for project grants for graduate training in public health, which will affect radiological health training; and
2. Proposed training grants to universities and other educational institutions specifically for training of radiation health specialists.

(Note: Since the symposium, both legislative training proposals were passed by the Congress and signed into law by the President.)

In the first category, which would enable project grants for graduate training in public health, the House of Representatives and the Senate have each passed legislation which would authorize the Surgeon General to make project grants "to schools of public health, and to those schools of nursing or engineering which provide graduate or specialized training in public health for nurses or engineers, for the purpose of strengthening or expanding graduate public health training in such schools." Although the Congress has recessed until August, it seems reasonably certain that the legislation will be enacted before the present Congress adjourns.

The first named grant program will be administered by the Division of General Health Services. Announcements of the expected availability of the grants, tentative terms and conditions, application blanks, and instructions have been sent to the schools.

Envisioned in these efforts to strengthen and expand graduate public health training in eligible schools of public health, nursing, and engineering are projects to improve and enrich the curricula to meet the needs of changing and emerging public health problems; projects to strengthen programs of basic training in public health administration; to develop and demonstrate public health training methods and procedures; and to enlarge facilities and supporting staff to provide for increased enrollments. The purpose is to augment the scope and quality of public health training programs rather than to replace funds now available for current operations.

The second category being considered is training grants for developing radiation health specialists. The Senate committee that governs our appropriations has recommended an additional $500,000 in the Division of Radiological Health budget expressly to inaugurate a program for such training grants. This recommendation has not as yet been taken up in a conference between the Senators and their House of Representatives counterparts, but we are hopeful that it will be accepted. As soon as this happens we shall establish mechanisms for implementing these training grants. The patterns for administering such grants within government are well established and our procedures undoubtedly will be comparable to those announced by the Division of General Health Services for the project grant program.

To summarize, we view this symposium as an important part of both the assessment of the national need and of ways to best meet these needs. As I have already indicated, the field of radiological health is so new, with the full impact of atomic energy yet to be experienced, that we must rely during this early stage on the assistance of universities in preparing the professionals needed now and in the future.

A number of things conspire to make this a rather unusual task. Some of these are the need for many professional disciplines in directing a program which affects the entire social structure, and the special need for assuring that we gain public understanding. In the final analysis it is the public we must serve in terms of health promotion and health protection, whether we operate in government or non-governmental programs. In each case it is the public that supports our efforts.

In organizing health efforts in the field of radiological health, an administrative approach quite similar to that of other national health efforts in the past and present can be applied. That approach usually follows this order:

(1) Defining the problem; (2) applying our knowledge in the various aspects involved; and (3) developing and guiding public opinion along sound scientific lines.

Therefore, as this symposium proceeds, we hope it can move closer toward establishing: (1) basic criteria for curricula as well as the content required at various levels; (2) examine the resources which universities may need to accomplish the purposes; and (3) indicate clearly the best course to follow during the ensuing weeks and months to accomplish the goals we have set.

The University's Role

Dr. Russell H. Morgan: In the future, I believe that our universities have a major responsibility to provide basic radiological health courses which will give any student who is likely to encounter radiation exposure problems in his profession a fuller appreciation of the hazards associated with such exposure and the background knowledge with which to deal effectively with them or seek assistance when they are beyond his capability.

I speak here of the student in medicine who may well use radiological methods in his practice and who now does so with little or no training in radiation protection and safety.

I speak of the student in nuclear engineering whose ultimate responsibilities may require him to make judgments on matters of radiation protection. If his education is deficient in this field, his responsibilities are not likely to be discharged effectively.

I speak of the chemistry student who after graduation may embark upon a career where radioactive materials are used extensively in his operations and yet who may receive little or no formal training in the handling of radioactive materials beyond those given in school.

And I speak of the students in political science, business administration, and other regions of the academic picture where responsibilities, health, and safety in the radiation field are not of prime importance but where background knowledge is an essential component of their education if they are to be practical citizens in this decade of 1960 and in the years ahead.

While the Atomic Energy Commission (AEC), and the U. S. Public Health Service (PHS) have performed superbly in providing radiological health training for individuals in some of the foregoing categories, there can be little question that the basic training in radiological health should be included as a fundamental component in any university program where students later are likely to use radiation as a tool in their work, or will have some aspect of radiation come into their thinking.

Indeed, I believe our universities which are not meeting this responsibility at the present time cannot afford to do so much longer, and here I speak of most of our universities, including my own.

Although frequently it has not been recognized as a university function to provide training for a student in basic health and safety aspects of a potentially hazardous technology, public opinion will soon require such recognition. Already, the public is concerned with those physicians who use fluoroscopes in their practice yet, during their medical school education, received little instruction concerning the hazards which the improper use of such apparatus is likely to create.

Thus there is a need for our universities to embark upon curricular changes which involve the inclusion of radiological health training in a variety of programs including medicine, engineering, the basic sciences, and some of the liberal arts. Although this role of the university in radiological training is distributed through many departments and hence somewhat diffuse in nature, it is nevertheless an important role.

Another role of the university in radiological health is in training those individuals whose primary vocational responsibility after graduation will be radiological health and safety. Twelve hundred such individuals will be required in the United States during the coming decade.

These individuals will hold either bachelor's or master's degrees in engineering or the basic sciences or doctor's degrees in medicine. They will require advanced training in a broad range of disciplines including physics, chemistry, biology at the fundamental level, radiobiology, radiation chemistry, health physics, and others at the applied level.

To meet the demand for persons who are able to lead in the radiological health programs of our Nation at the governmental, industrial, medical, research, and laboratory levels, the training provided these students must be comprehensive.

For some, this means work equivalent to that needed for a doctor's degree, sufficiently intensive to require the student to spend a minimum of 2 and preferably 3 years before completion.

For those who are likely to assume more subordinate positions in radiological health programs, it means at least the completion of 1 and preferably 2 years intensive training in radiological health subjects at the basic and applied levels and sufficiently comprehensive to justify the award of a master's degree.

The establishment of comprehensive graduate programs in radiological health within our universities will not be easy. Men suitable for a faculty in radiological science are in short supply. Students entering radiological science with a diversity of backgrounds will require a broad complement of introductory courses in science to reach a scientific common denominator.

For the engineer, work in a number of biological sciences will be a prerequisite to a course in radiobiology; for example, for the medical student, work in mathematics and physics will be required. To both, work in physical chemistry and biochemistry will be needed before courses in radiation chemistry are encountered.

Another problem facing the university embarking upon a program in radiological science is its high cost per student. The instructor-to-student ratio must be low necessarily if the student is to be guided through a complex range of disciplines within the relatively short time period. Also, the financial outlay to equip student laboratories is unusually high. As a result, cost per student-year are likely to range anywhere from $8,000 to $30,000. Most schools must seek outside support to permit them to develop radiological training.

The largest source of university support today is the Federal government, and I am sure all of you were happy to hear that steps are being taken to provide this support.

With adequate support from Congress and with 10 or 15 of our leading universities now embarking upon comprehensive radiological science programs, and many others upon smaller programs, there seems little doubt that the need for 1,200 radiation health specialists by 1970 can be met, if there is recognition by our universities that they have a role and a responsibility to play in the training of such men.

Although other avenues are open wherein men can be trained to the master's or doctor's level in radiological health, or the equivalent of these levels, the university is the place to which one turns naturally for leadership. Historically, the university has always been quick to accept such a challenge. There is no reason to expect that conditions will be different now.

In fact, as Great Britain's Committee on Training in Radiological Health and Safety has pointed out, the university must accept this role. Any other solution to the problem of training in radiological health would be unsatisfactory.

Fortunately, as is the case in Great Britain, our universities are willing and anxious to accept the challenge. They await only the leadership that perhaps this symposium can supply and, therefore, let us work during the next few days to lay out the blueprint for a sound academic training program in the field of radiological health, to assess clearly the factors which determine curriculum, and to indicate the means whereby a radiological health program may be placed in full operation.

I have not dealt with the place of the university in research, since this is so well known that it needs no further discussion.

Also, I have not dealt with the role of the university in aiding the government to develop its programs. In our National Institutes of Health, the research and training programs have depended very extensively on university people to supply the mechanisms for disbursement of research and training funds. I can see the time coming quickly in the Division of Radiological Health, as training and research funds become available, when many of you will be called to serve in capacities similar to the capacities served by you and your colleagues in the universities of this country on radiation and in other study sections of the Institutes.

Health Department Needs

Karl M. Mason: In addition to the State Health Department, Pennsylvania has only one local health department active in radiological health activities. The total staff thus employed, though, would be quite similar to States with an equal population. It just happens that in Pennsylvania we have yet to develop extensive local health services.

The other four areas in our State which have local health units employ some 70 professional and technical environmental health workers. Undoubtedly these departments will become more active in radiation control as time goes on, especially if they are able to secure the necessary training for their staff.

Our State radiation activities began back in the early 50's when our industrial hygiene staff cooperated with the Atomic Energy Commission in the inspection of isotope licenses. It was not until 1955 or 1956, however, that we became involved with users of larger amounts of radioactive materials and the first was a power reactor at Shippingport. Here we had a proposed facility which planned a discharge of comparatively large amounts of liquid waste, a field of control heretofore within the realm of the sanitary engineer, but for sewage and the more conventional industrial wastes, not radioactivity.

Without going into the details of that particular operation, I believe I can state that with the cooperation of the Public Health Service, the Atomic Energy Commission, the Duquesne Light Company and its consultant, Westinghouse, this problem was handled to the satisfaction of everyone concerned. Witness the tremendous job that was done at the public hearing in Wheeling, W. Va., by most of these agencies to allay the fears of the residents that they might suffer ill effects from excessive radioactivity.

Since Shippingport, eight or ten other types of nuclear facilities have been constructed in our State, and on the basis of the Shippingport experience, adequate controls for liquid, gaseous, and solid wastes have been established.

Now, regardless of recent comments concerning our "unrealistic standards," reported in scientific journals at the time of the incident at the Westinghouse Waltz Mill reactor, we believe that standards applied to nuclear facilities in our State have been and are realistic, even though they may, in certain cases, be more stringent than nationally recommended MPC's.

The point I am trying to make is that radiation has become a part of the sanitary engineer's responsibility for liquid waste control and the air pollution engineer's responsibility for gaseous waste control.

We have been able to move ahead because of intensive in-service training programs using the instruction and consultation provided by the Public Health Service, the Atomic Energy Commission, and the universities. But this course is certainly not good enough for the future.

In our own State Bureau of Environmental Health, for instance, only 3 persons, the health physicist, the chief industrial hygienist, and one sanitary engineer among a staff of 338 professional and technical employees, have had specialized graduate study of a year or more in this subject. And in the one local health department carrying out radiation protection activities, only 1 among 74 professional and technical employees has received such training.

Thus the potential in our State is some 500 environmental health personnel who are eligible for advanced academic study of some type.

You can imagine from these figures the training burden placed on the departments, and the Federal agencies cooperating with them, in preparing their staffs to cope with the problems of more than 8,700 sources of ionizing radiation so far registered throughout the State. In addition to the medical and dental facilities and the power reactors, these radiation sources also include fluoroscopes of various types, radium, radioisotopes used in medicine, agriculture, and industry, testing reactors, research reactors at industries and educational institutions, decontamination laundries, and fuel element fabricating plants.

It is to the educational institutions that we look for the solution of our future staffing problems.

Today, most State and local health departments employ only college graduates in their professional and technical positions. Therefore, since almost all such staff members in modern health agencies become involved sooner or later with radiation protection activities, we hope that the engineer, the chemist, the biological science major, the physician, and the dentist will receive more and more basic education in this field, with some appreciation, if possible, of the health effects of overexposure.

On this groundwork, the official agencies can supply additional training more rapidly than at the present time through the use of the many resources at their disposal. We hope that the graduate schools will include more course content on this subject for staff members needing more advanced training in this scientific field.

As an example of the opportunity for graduate education in this field, our department will send ten staff members from our bureau alone for graduate study this fall -- four engineers, three sanitarians, an accident prevention specialist, a physician, and an industrial hygienist.

When one of our engineers, for instance, returns with a MPH or an MSSE, we feel quite certain that he has received instruction and stimulation in the field of water resources conservation as well as in other major public health subjects. He knows much more about the need for and the method of supplying, adequate treatment of domestic and industrial wastes, including some of the newer and troublesome organics and toxicological waste. We hope that soon he will receive, as a basic part of his instruction, similar knowledge in the field of radiological health.

So it is with our physicians, dentists, nurses, industrial hygienists, sanitarians, chemists, and all the other professional staff members. As such individuals develop to the point where an official agency is willing to spend time and money on their advanced study in public health, they usually occupy a position in that agency which requires them to become involved in that increasingly important public health program -- radiological health.

We hope that both undergraduate and graduate schools will expand their instruction in this field so that members of all health department staffs will have the opportunity to become more skilled in carrying out their program responsibilities.

Radiological Health Personnel Requirements

James G. Terrill: Because teaching and research commonly are combined as a university staff function, it may be well at this time to review some of the major research problems facing health agencies during the foreseeable future.

One of these is an extension of specific-cause-and-effect relationships which population groups and long-term, low-level, radiation exposures may create. Methods of reducing population exposure, particularly medical X-ray, further study of the mechanism of radiation injury at the molecular level, and further refinement of waste-disposal criteria, are typical research areas. However, quantitatively and qualitatively, I believe that perhaps other participants in this conference can describe these needs far better than I can.

I will go into some detail with regard to health protection and control programs, indicating a system which lends itself to estimating personnel requirements.

Medical Radiation Physicists, as I have designated the first category, will be required in major hospitals and health agencies to assist physicians and dentists in the application of radioactive materials and to promote and operate a radiation-control program. It is expected that they would operate under the technical direction of a committee which would supply broad guidelines and serve as an intermediary with the various professional groups.

Their duties would encompass recommendations relative to apparatus and technique for the minimum dosage use of X-rays and radionuclides, planning and assisting with pertinent monitoring programs, maintaining patient follow-up records regarding acute and chronic radiation exposure, and maintaining records of the exposure of the staff. In some instances, the medical radiation physicist would be expected to work closely with the pharmacists or the radiochemists in the development, application, use, and disposal of radioactive drugs and wastes. As far as I know there isn't any official definition for personnel in this general category, so I submit this suggestion to you on a trial basis.

The term health physicist, as defined by the Health Physics Society, is a broad term applicable to almost any radiation protection situation. The definition reads:

"A health physicist is a person engaged in the study of the problems and practice of providing radiation protection. He is concerned with an understanding of the mechanisms of radiation damage, with the development and implementation of methods and procedures necessary to evaluate radiation hazards, and with providing protection to man and his environment from unwarranted radiation exposure."

I quote this definition to you because, believe it or not, at meetings like this, people will say, "What is a health physicist?" This is what the Health Physics Society believes the health physicist is. For purposes of my discussion here, though, I would like to narrow this definition a little bit. The profession grew up in the nuclear industry and is expanding into the health agencies. Presently it is principally related to industrial radiation detection programs and normally, the health physicist develops his program from the source and works toward the exposed or potentially exposed people. He studies all of the potentialities of the source in its designed, operational, and waste form, and devises methods of measuring potential and actual exposure from this source under operating conditions. Generally, he serves as an adviser to operating personnel and depends upon the operator to carry out the routine task of providing radiation safety for the operating staff.

The reactor safety engineer, a third personnel category, as defined for purposes of tabulation here is usually concerned with the planning of major sources. Based upon theoretical knowledge and past experience covering both the ideal, normal, and emergency operating conditions, he attempts to create structures which will meet the criteria established by the scientists and responsible control groups.

In this capacity, he must have knowledge of the actual performance of machinery and instruments under the limitations of design, integration of the components into the several assemblies, and the operation of this equipment on a continuing basis over a long period of time, under the supervision and control of the types of personnel actually employed -- professional staff, technicians, and skilled and unskilled workers. He must take into consideration not only the types of materials and the desirable tolerances but also the types of materials and the limitations of any system of inspection actually in existence. He is also expected to look back on the past theoretical and practical mistakes and successes and work with his several engineering and scientific colleagues to develop codes and practices which will place a majority of the routine engineering involved into understandable codes and practices, without stifling the initiative of individuals in their efforts to improve the art.

Sanitary engineers, the fourth category, like the health physicists, have a very broad official definition for their profession. I won't attempt to quote it all. Briefly, it says, "The practice of sanitary engineering includes the following activities: Water supply, sewage and sewage treatment, milk and food, housing, insect and rural sanitation, control of atmospheric pollution, prevention of radiation exposure and professional research, development and training activities connected with these specific items. . . Sanitary engineering is concerned with problems that require careful scientific analysis and sound engineering and economic solutions if man's physical environment is to be developed and maintained in a way conducive to his physical and mental well-being."

For purposes of this symposium, sanitary engineers must have a knowledge of radiation sources and how these sources may become contaminants through corrosion, chemical processing, leakage in primary protective barriers and shielding, fallout, and intentional discharge to disposal systems. He must understand the ways in which these wastes can be estimated long before they are created, on the basis of the energy potentials of the source over a period of time. He must make relatively accurate estimates, and provide flexibility to cover his inadequacies for handling and disposing of the wastes in the form, volume, and weight in which it is created. He must make provision for, and measure, the radioactivity at the point of discharge, and estimate its effect upon the environment.

Dr. Morgan had little different terminology for the category which I have termed "radiological health generalists," but I think it is good that we have introduced different terms, at least at this stage. Perhaps we can agree later. These generalists will be called upon for direction and leadership in overall protection and control programs, and will require knowledge of radiological health as integrated into public health practice. Thorough training is required in radiation epidemiology, application of radiation guidelines, and the effects, in toto, of radiation upon society. A number of types of people may be fitted into this category, depending upon their training, experience, interests, and proven ability. These include:

Physicians with radiological training and with special experience and proficiency in radiation protection;

Dentists with special training and with experience in radiation applications and protection;

Fully trained physicists, radiological physicists, and engineers with special background interests;

Public health administrators with specialized training and experience; and

Research personnel at upper levels of radiobiology, genetics, health physics, biophysics, and like sciences.

This list represents perhaps just some of the major professional groups which could be listed or tabulated, and I have chosen these so that you will have a base for your considerations in the specific conference groups.

To provide some guidance as to the numbers required in the five above-named disciplines, estimates are given in the following tables of the number required as employees in the United States for the year 1970. These projected professional personnel requirements are tabulated for industry, the medical, university, and research institutions and for the health protection and control agencies.

Projected professional personnel requirements in industry:

Profession	Industrial Operation				
	Raw materials production	Military and power reactors	Radionuclide uses	X-ray uses	Independent consultants
Medical radiation physicists	--	10	50	10	50
Health physicists	50	400	300	50	100
Reactor safety engineers	--	100	--	--	50
Sanitary engineers	60	300	100	--	100
Radiological health generalists	10	50	50	10	100

Projected professional personnel requirements in medicine, universities, and research institutes:

Profession	Area of Requirement		
	Hospitals	Universities	Research institutes
Medical radiation physicists	300	50	20
Health physicists	100	100	100
Reactor safety engineers	10	50	50
Sanitary engineers	50	50	70
Radiological health generalists	50	50	20

Projected professional personnel requirements in health protection and control agencies:

Profession	Area of Requirement		
	Federal	State and local	Other agencies, labor, insurance, etc.
Medical radiation physicists	30	100	20
Health physicists	50	200	30
Reactor safety engineers	50	50	20
Sanitary engineers	80	200	30
Radiological health generalists	50	200	30

Summary of projected professional personnel requirements:

Profession	Area of Requirement			Annual candidate needs (assuming an attrition of 33 percent)	Estimated present training rate
	Industry	Medical, university, and research	Health protection and control		
Medical radiation physicists	120	370	150	100	10
Health physicists	900	300	280	220	90
Reactor safety engineers	150	110	120	60	20
Sanitary engineers	500	170	310	150	50
Radiological health generalists	220	120	280	90	30
Total	1,890	1,070	1,140	620	200

You will note that in these estimates, the health physicist and the sanitary engineer are the primary need in industry. The health physicist and the medical radiation physicist represent the larger requirement in estimated medical, university, and research needs, and the health physicists, the sanitary engineers, and the radiological health generalists are the larger groups required by health protection and control agencies.

In the summary table, we have estimated the annual candidate needs.

You will note about 1/2 the total health personnel are needed in industry, 1/4 in hospitals, universities and research organizations, and 1/4 in health agencies. The total required outside industry (2,210) compares favorably with the Veale report for England, i.e., 500 times four-fold difference in population, or about 2,000. The total "annual candidate needs" are 620. Comparison should be made with university candidates entering the radiation-use field. The candidates including the medical profession, are estimated at about 20,000 and 620 represents about 3 percent of this total.

Apparently you end up with a need for thousands and an annual need of hundreds, regardless of the criteria you choose for your estimate.

Many people believe there is a need also for technical-level support personnel, in view of the inordinate amount of time that must be expended in routine instrumentation and analytical procedures. Such technicians might serve as survey instrument operators and as laboratory instrument operators or sample processing analysts.

Currently, high school graduates are sometimes employed as technicians and, all too frequently, the professional staff is involved as well. As a compromise, it has been suggested that the 2 year college be invited to recommend possible training. In terms of quantitative needs of the two types of technicians indicated above, 2,000 survey instrument operators, and 2,000 laboratory technicians would be required. This is equivalent to an annual need of 300 candidates for each of these categories.

I hope that the recommendations of the symposium will make some comment upon this.

There are other professions that must be considered. Because radiation sources typically represent a hazard potential of deadly proportions, and since it is impractical that a full-time radiological health official be readily available in most instances, it is important that training at least at a rudimentary level be given to personnel responsible for the management of such sources.

All public health officials, educators, and information personnel should also gain a conceptual knowledge of the radiological health field. And in addition, personnel responsible for the design or operation of water and sewage systems should have training pertinent to the radioactive waste problem.

Such training should preferably be integrated into the regular curriculum, in such courses as radiology in the medical schools, or industrial wastes in the engineering schools. To supply such training to present-day workers necessitates special radiological health orientation courses, or you might call them topical training courses, such as AEC has provided at some of its installations and such as we provide in cooperation with universities and at the Sanitary Engineering Center.

Through the professions, the public as a whole must assimilate knowledge and opinions about radiation, since it is associated with major defense equipment, basic energy resources, and to a large extent, major public expenditures.

National policy decisions should reflect an intelligent appraisal by the electorate, which, in the final analysis, guides political destinies.

Health Physics Society

Dr. Elda E. Anderson: I shall speak first about the Atomic Energy Commission fellowship program in health physics with which I have been associated for the past 11 years.

The program began in 1948, 12 years ago. At that time, it was known as the fellowship program in radiological physics. I think you can readily see that very quickly we ran into difficulties because of the name. Many applicants who might have been interested in a radiation protection program or a health physics program, saw the word "radiology" and lost interest. As a result, the fellowship program was later renamed the AEC Fellowship Program in Health Physics. Thus health physics became clearly recognized as a profession. The organization of the Health Physics Society a few years ago gave further affirmation of the fact that health physics is a profession, a profession whose primary purpose is the protection of man and his environment from unnecessary radiation.

The purpose of the fellowship program is not only to train those persons primarily interested in health protection and health control but also to attract those persons interested in research in the field of radiation protection. This would cover Groups II and III discussed by Mr. Terrill.

The program began in a very small way at the Oak Ridge National Laboratory (ORNL), and at the University of Rochester. At that time, the program was administered by the National Research Council and supported by the AEC. Many of the leaders in the field of health physics today came from these early groups.

During the first 2 years of the program, a number of courses were taught at the Oak Ridge National Laboratory: calculus for those who had no such course in their undergraduate work, an intensive course in atomic and nuclear physics, biology including radiation biology, and electronics.

During the spring of 1950, the question was raised as to whether the Fellows should be enrolled in a university since it is the inherent function of the university to teach. Vanderbilt University was selected as the school to work with the Oak Ridge National Laboratory in the Fellowship Program. At the same time, the Brookhaven National Laboratory was asked to provide on-the-job training in health physics for the University of Rochester Fellows. In the Fellowship Program, the students spend 9 months at a university, followed by 3 months at an AEC installation in applied health physics training.

Another basic reason for bringing the universities into the program was graduate credits. Fellowship applicants were required to have a bachelor's degree in physics, chemistry, engineering, or biology. Upon being accepted they took the equivalent of a year of graduate work. Since ORNL is not a degree-granting institution, the Fellows at ORNL received no credit for their year of graduate study.

In the 12 years since its inception, the program has developed and grown. The curriculum has changed as the needs of the health physics profession have expanded and changed.

At Vanderbilt University, the emphasis from the beginning has been on physics since physics is recognized as the fundamental science in the detection and measurement of ionizing radiation. In addition, mathematics, radiation chemistry, and electronics are stressed. All students are required to take a course in atomic and nuclear physics if they have not had an adequate course in their undergraduate program. All are required to take a course in radiation biology. Many of the physics majors entering the program have had no course in a biological science to prepare them for the radiation biology course, and therefore they are required to take elementary biology which does not carry graduate credit. Beginning this fall, Fellows entering Vanderbilt University will be required to take an examination in biology. The decision as to whether they need more work in biology before they are ready for radiation biology will be based on the results of this test.

Another required course is applied radiation physics. This is taught by the Oak Ridge National Laboratory staff. It is a graduate course -- 4 credits a semester -- in which the fundamental principles underlying health physics problems are stressed. I am happy to say that many of the nuclear engineering students at Vanderbilt also take this course.

Many of the students in health physics go to the Nuclear Engineering Department for the course in reactor theory. For those who cannot fit the reactor course into their program at Vanderbilt, a brief course in the fundamentals of reactor theory is taught at the Oak Ridge National Laboratory during the summer. In this nuclear age, those responsible for the control of radiation hazards around reactors must know the fundamentals of reactory theory.

After 9 months at Vanderbilt, the Fellows spend the summer months at Oak Ridge National Laboratory. The University of Rochester students go to Brookhaven. Other universities in this program are affiliated with other AEC installations.

The 3 summer months at an AEC installation are an extremely vital part of the training program. The big hazards in radiation today lie around reactors where people can be hurt in a microsecond -- around accelerators, in the chemical processing of reactor fuels where not millicuries or microcuries but thousands of curies of radioactive material are handled, in the mining of radioactive ores, and in the fabrication of fuel elements. I personally would feel uneasy if any student left a university to work in health physics without having, under close supervision, the experience of protecting himself and others from hazards of this kind. The students spend the 3 summer months out in the field working under supervisors who have had many years of experience in handling radiation.

The program at ORNL acquaints the Fellows with a wide variety of situations. There are reactors, many in number; fuel-element processing; a large research program; accelerators; cyclotrons; criticality experiments; waste disposal and environmental problems; in short, all the many problems in radiation control associated with a large AEC installation. In addition, an attempt is made to give the Fellow an introduction to some of the research problems associated with radiation protection. This summer, the group at ORNL is compiling data in dosimetry, assisting on a waste disposal research problem, and calculating an internal dose. By the end of the summer, the health physics students will have become acquainted with research in some of the fields of health physics.

The Fellows who finish the year with outstanding academic and applied training records are given an extension of their Fellowship to complete the requirements for a master's degree.

What do the Fellows do at the conclusion of the Fellowship program? What kind of jobs do they accept? Many are associated with AEC installations. One of the original purposes in establishing the program was to provide new AEC installations with qualified health physicists. Some of the Fellows are with the AEC in the Inspection Division, in the Division of Licensing and Regulation, in the Division of Biology and Medicine, and in other divisions.

A large number of the Fellows are at universities and are responsible for radiation protection and control programs; some are teaching health physics courses.

Hospitals have provided openings for the students. The U. S. Public Health Service has employed many graduates of the AEC Fellowship Program. Quite a number of the Fellows fulfill their 2-year military commitment very effectively in this way.

As the need for trained health physicists grew, other universities and AEC installations came into the program. A total of seven universities participate today: the University of Rochester, Vanderbilt University, the University of Washington at Seattle, the University of Kansas, Harvard University, the University of California at Berkeley, and the University of Michigan. The AEC installations providing summer training are Brookhaven National Laboratory, Oak Ridge National Laboratory, National Reactor Testing Site, Hanford Atomic Products Operation, Argonne National Laboratory, and the Lawrence Radiation Laboratory.

The program has shown steady growth, but always the limitation has been the number of acceptable candidates. The applicants must have a bachelor's degree in one of the physical sciences, biology, or engineering, and a good academic record to be acceptable to the graduate school of the university. The primary aim is to train people at the master's level.

The stipend was increased and yet the number of applicants did not increase. Whether you are in a university or in the business of hiring engineers and scientists such as physicists, chemists, and biologists, I know you all realize the supply of graduates with degrees in science and engineering is limited.

We have increased the number of applicants in the past few years by going out and beating the bushes. We have held symposia the past 2 years that have been successful in interesting more applicants in the program. Since 1950 we have received approximately 1,600 applications and have trained 567 Fellows. The first 2 years of the program are not included in these figures. The total number trained is closer to 600.

A year or two ago, the AEC noted that the majority of experts in health physics were doctors of philosophy in the physical and biological sciences who had entered the field during or immediately after the war, and that few of the AEC Fellows were continuing or returning to further graduate study due to the acute demand for health physicists and the high salaries paid.

To ensure a continuous supply of Ph.D.'s in the field of health physics, an advanced training program that leads to the doctoral degree was instituted. One student in this advanced program received his degree at the University of Michigan this June. The program has been in existence 2 years with five students each year. The stipend is generous. The applicant must have had not less than 2 years of experience in the profession of health physics and must have shown a genuine interest in the field. The degree is to be taken in a field which contributes directly to health physics.

Last spring, a 10-week course in health physics was offered by ORNL and Oak Ridge Institute of Nuclear Studies (ORINS) for personnel from the AEC and State departments of health. The course was designed to train State personnel for taking over the regulation and inspection functions of the AEC. We were disappointed in the number of applications received. Although the number of participants had been limited to 20, we had to make up that quota by accepting military officers and additional AEC personnel who wished training in health physics. A similar course will be offered in the spring of 1961, and it is hoped that the number of applications from State departments will show a substantial increase.

The Health Physics Society was formed in 1956, and its formation was stimulated largely by graduates of the AEC Fellowship Program. The membership of the society today is over 1,300.

Since its establishment, the society has had a committee working on the problem of the certification of health physicists. Members of the profession have been concerned about persons accepting positions in health physics for which they are not qualified. The acute shortage of health physicists has encouraged this practice. I personally know of a case where a person, with about 6 months experience as a surveyor at an installation having a fine health physics department, was offered and accepted the responsibility for the health physics department in a large organization. He lasted but a short time in the new job because someone found out that he was not a qualified health physicist. Situations of this kind made it necessary for the society to undertake a certification program.

Today, the American Board of Health Physics, Inc., is established and, within a month or two, certificates will be issued to qualified health physicists. The first examination for certification was held at the annual meeting in Boston, Mass., in June 1960.

What are the qualifications for certification as a health physicist? To be certified, a person must have a bachelor's degree in either a physical or a biological science or engineering. If he majored in engineering or biology, he must have a strong minor in physics. In exceptional cases where persons have demonstrated that they have an adequate knowledge of health physics but are deficient in formal requirements, they may be permitted, at the discretion of the board, to substitute experience for academic requirements. Some of today's health physicists came into the field at a time when the demand was great and when the educational qualifications of today were not required.

All applicants must have at least 5 years of responsible professional experience in health physics and must be devoting a very substantial portion of their time to health physics. One year of graduate work in a discipline which is closely related to health physics can be substituted for 1 year of experience, up to a maximum of 3 years. After December 31, 1960, an examination will be required of everyone who wishes to become certified as a health physicist.

The profession of health physics expanded during World War II and has developed at an accelerated rate since that time. The need for qualified health physicists is still acute and will remain so until the number of scientists and engineers graduated from our colleges and universities increases.

Engineering Societies

Dr. August T. Rossano: Although the invitation to participate in this conference came to Dr. Jack McKee in his capacity as past chairman of the Committee on Engineering Education of the American Society of Civil Engineers (ASCE), he and I have taken the liberty of broadening the coverage of this paper to include a discussion of the interests of all major engineering societies in education for radiological health, inasmuch as these interests are interrelated and overlapping. Engineering societies tend to function cooperatively in areas dealing with engineering education. This cooperation is generally effected through the Engineers Joint Council and through the Engineers' Council for Professional Development (ECPD). The various disciplines and specialties of engineering also find a common meeting ground in the American Society for Engineering Education (ASEE). And, in the case of sanitary engineers, six organizations have banded together to form the American Sanitary Engineering Intersociety Board (ASEIB).

All of these cooperating agencies, as well as the individual professional societies, maintain a strong and continuing interest in all aspects of engineering education.

In this paper, the interests of these various intersociety groups will be described. Then, the specific interests of the American Society of Civil Engineers will be discussed in more detail. ASCE should be considered, however, merely as an example of how one of the large engineering societies functions in this respect. A similar picture could be drawn for the American Institute of Chemical Engineers, the American Society of Mechanical Engineers, and other groups.

While this paper is intended to be largely descriptive, it contains a few opinions and prognostications. They are intended to represent the views of the authors only and do not constitute the official position of the American Society of Civil Engineers or any of the other engineering societies.

A word about the role of the engineer in radiological health. The primary objective of radiological health is the protection of the populace from the deleterious effects of radioactivity. Much of this protection involves engineering, such as the construction of effective shielding or the treatment and disposal of radioactive wastes. Indeed, engineers are involved in almost every phase of the use of radioactive substances.

Subsequent speakers will describe the role of the engineer in radiological health in much greater detail. It is important here to note, however, that civil and sanitary engineers are not the only types of engineers concerned with radiological health. The subject permeates all fields of the engineering profession, including chemical engineering, mechanical engineering, and geological engineering, to name but a few.

I would like to outline briefly the intersociety organizations and their interest in engineering education.

Engineers Joint Council (EJC) consists of ten constituent societies, three associate societies, and eight regional groups. Its interests are largely in the technical and professional aspects of engineering, but its Engineering Manpower Commission is vitally concerned with engineering education, especially as it is related to the quantity and quality of engineering graduates. For the most part, however, EJC leaves detailed matters of engineering education to another intersociety group, namely Engineers' Council for Professional Development, which comprises many of the same organizations, or to one of its own constituent societies, the American Society for Engineering Education.

Engineers' Council for Professional Development has eight constituent societies. As its name implies, it is interested in all phases of professional development, but its primary emphasis and indeed the reason for its creation lies in the inspection and accreditation of engineering curricula. ECPD is recognized by the National Commission on Accrediting as the sole agency to coordinate and handle accreditation of engineering curricula. All of the engineering societies defer to ECPD in this respect. On the other hand, ECPD looks to one of its constituent societies (The American Society for Engineering Education) for criteria or guidelines to be used by inspecting teams.

The American Society for Engineering Education, as the name implies, is concerned with all aspects of the educational problem, on the undergraduate and graduate levels. The purpose of the ASEE is the advancement of education in all of its functions which pertain to engineering and allied branches of science and technology, including the processes of teaching and learning, research, extension services, and public relations. One of its major branches, the Engineering College Research Council, assists in developing research facilities in engineering colleges and serves as an organization to promote and coordinate scientific and industrial research. Through its various divisions and committees and especially through its collaboration with the accrediting activities of ECPD, the American Society for Engineering Education is the focal point for all matters dealing with the development of curricula.

The American Sanitary Engineering Intersociety Board is a joint effort to coordinate the sanitary engineering interests of the American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute of Chemical Engineers, American Water Works Association, Water Pollution Control Federation, and the American Public Health Association. It is interested in the development and advancement of all aspects of sanitary engineering, one important phase of which is education. On June 27-29, 1960, ASEIB sponsored a "Curriculum Study Conference for Graduate Programs in Sanitary Engineering" at Cambridge, Mass., with the financial assistance of the National Science Foundation.

The final report of this conference contains the papers that were presented, the resolutions adopted, and recommendations or guidelines for curricula in several aspects of sanitary engineering. The field of radiological health is an important aspect of the curricula in public health engineering and also in air resources. Without a doubt, subsequent speakers will discuss the recommendations of this conference in considerable detail.

Perhaps more than any other major engineering society, the American Society of Civil Engineers is interested and concerned with problems of education as they relate to all phases of sanitary engineering, including radiological health. For this reason, it may be of interest to examine the structure of ASCE to show how its various subdivisions relate to this problem.

The activities of ASCE fall largely into two categories: those dealing with professional aspects and those related to technical functions. The professional activities are carried out through a series of committees, of which the Committee on Engineering Education is of primary concern to this conference. This committee looks after the interests of ASCE in all matters of engineering education, cooperating with the similar committees of other societies and especially with ECPD and ASEE. This committee was instrumental in promoting the curriculum study conference sponsored by ASEIB and also a conference on civil engineering education at Ann Arbor, Mich., in July 1960. The committee recommends a list of civil engineering inspectors to be called upon by ECPD in connection with accreditation visits.

The technical activities of ASCE are carried out largely through 14 technical divisions, of which the Sanitary Engineering Division, the Power Division, and the City Planning Division are most interested in problems of radiological health. In addition, however, the Construction Division and the Structural Division are concerned with nonhealth-related aspects of nuclear energy, primarily in connection with construction.

The Sanitary Engineering Division of ASCE has a committee on the sanitary engineering aspects of nuclear energy, of which Mr. James G. Terrill, Jr., is chairman. Several other participants of this present conference are members of this committee. Its purpose is to advance the body of knowledge involving sanitary engineering and radiological health; to stimulate interest and activity in this field by sanitary engineers; to increase the sanitary engineers' know-how in this field; to recommend committees for special task investigations and reports; and to recommend publication of manuals and papers on subjects in this field. Many of the other committees of the sanitary engineering division are interested in radioactive substances, especially the Committee on Atmospheric Pollution. Since radioactive materials represent a hygienically significant class of airborne pollutants, the Committee on Atmospheric Pollution is understandably concerned with radioactivity in the air.

The City Planning Division of ASCE has a committee on land use aspects of applied nuclear energy. The purpose of this committee is to identify current and probable applications of nuclear energy; to study the evolving space requirements and hazard potential of these applications; and to set practical standards on which the formulation of effective land use controls and safety measures can be based.

The Power Division of ASCE has a committee on nuclear power. Its purpose is to investigate and disseminate information relating to the economics and civil engineering features of nuclear power plants, including radioactive waste disposal, and to cooperate in the exchange of information with similar committees formed by other bodies.

In July 1960, ASCE, ASEE, the Cooper Union, and the University of Michigan collaborated in a conference on civil engineering education under the financial sponsorship of the National Science Foundation. The theme of this conference can best be expressed by a resolution submitted by the conference planning committee, around which the entire program was developed.

The delegates to the conference have not yet voted on this resolution or on others submitted subsequently, but from the entire tone of the conference, it was apparent that this resolution will have the wholehearted support of most engineering educators. Because it is germane to the whole subject of university curricula, the resolution is quoted in its entirety:

"Whereas the report of the ASCE Task Committee on Professional Education, published in 1958, revealed that a large proportion of the membership believes that contemporary civil engineering education falls far short of meeting contemporary needs, and

"Whereas two-thirds of the membership favors extending the period of undergraduate study to 5 years, and

"Whereas the work of the civil engineer is becoming increasingly interwoven with and vital to man's economic, political, and social well-being, and

"Whereas modern technological developments are ever widening the vistas of civil engineering and deepening its scientific roots, and

"Whereas these trends are constantly accentuating and creating needs that can be met only by truly professional people whose education has the breadth of a liberal education and the depth of a firm foundation in mathematics and science, and

"Whereas professional education can fully realize its objectives only as it can grow out of the breadth and depth of preprofessional studies, and

"Whereas a learned profession will grow and prosper in proportion to the creativity and vision engendered by continuing research and study at its frontiers,

"THEREFORE BE IT RESOLVED that this conference favors the growth in universities and colleges of a pre-engineering, undergraduate degree-eligible program for all engineers, emphasizing humanistic-social studies, mathematics, basic and engineering sciences with at least three-quarters of the program interchangeable among the various engineering curricula; to be followed by a professional or graduate civil engineering curriculum based on the pre-engineering program and leading to the first engineering degree, with a civil engineering degree awarded only at the completion of the professional or graduate curriculum, and

"BE IT FURTHER RESOLVED that increasing opportunities should be provided for qualified students, by progressively more advanced study and research, to earn graduate degrees at the master's and doctor's level, and

"FINALLY BE IT RESOLVED that engineering societies in ECPD and EJC be advised of this resolution and be urged to support it by concurrent resolutions in order that unified action will be taken to secure a truly professional educational base for professional engineering practice."

The trend in engineering education today is decidedly toward more basic sciences and mathematics, more engineering sciences, and more humanistic-social studies in the undergraduate curriculum. In essence, the undergraduate engineering program is becoming a pre-engineering preparation. Because the undergraduate curriculum is becoming too crowded with basic and humanistic courses, subjects dealing with the application of fundamental scientific principles to specialized areas will have to be taught in the graduate schools or professional schools. Education and training in radiological health belongs in this latter category.

A student with a sound pre-engineering education, or perhaps an education in one of the scientific disciplines such as physics or chemistry, should be well prepared to tackle advanced subjects on the graduate level and he should be particularly well-grounded for training in many of the aspects of radiological health. Since education on the undergraduate level will tend to be confined to fundamental principles, the applications will have to be deferred to the graduate level. It is anticipated, therefore, that courses in radiological health will be taught largely at the master's or post-master's level of education.

In summary, the trend in engineering education today is toward a pre-engineering scientific education on the undergraduate level followed by professional training in specialized courses at the graduate level. The field of radiological health depends on a good foundation in basic science, but instruction in the detailed features of this subject should be confined to the graduate level. It is anticipated that the engineering societies will support this philosophy and will encourage accelerated training in radiological health in graduate or professional schools.

American Medical Association

Dr. Ralph E. De Forest: From the standpoint of a discussion of the radiological sciences and radiological health, probably two areas of concern within the American Medical Association (AMA) are physician education and medicine's relationships with allied health professions.

Information available from the office of the Council on Medical Education and Hospitals indicates that undergraduate medical education in the medical schools of the country has included instruction in various aspects of the radiological sciences and radiological health. The subject matter has been integrated generally into the teaching program, without following any specific nationwide pattern. Thus, material is presented in various ways and amounts in the different schools throughout the country. There has then been a free and consequently healthy growth and development of curriculum content up to the present time.

It is, however, entirely conceivable that it would be advantageous to prepare a basic recommendation, outline, or guide as to what every medical student should know about the radiological sciences by the time he completes his undergraduate training. The Council on Medical Education and Hospitals is interested in reviewing suitable recommendations in this regard so that, if appropriate, they might be disseminated to the various medical schools.

Within the field of graduate training, residency training, the university curriculum does not play too great a role. Most of the residency programs for physicians seeking training in the specialty areas of medicine are conducted in hospitals not associated academically with the medical school or university. However, in some instances these residency programs or fellowships are a distinctive part of the university situation and lead to the acquisition of a postdoctoral degree. Where this is the case, improvements in the university curriculum for this group of students cannot help but have a salutary influence on the programs not conducted under the auspices of the university.

It is interesting to note in reviewing the report by the Council on Medical Education and Hospitals of the American Medical Association entitled "Essentials of Approved Residencies," that of the 21 branches of medicine for which there are approved residencies, there is only one, radiology, which distinctly and clearly calls for training in the radiological sciences. In another specialty, dermatology, the desirability for training in the radiological sciences is suggested through a reference to the broader field of biophysics.

This conference may wish to give some consideration to curriculum needs at the level of medical specialty training. Radiation problems are reaching ever-increasing magnitudes for physicians previously not so concerned in the field of preventive medicine, internal medicine, pathology, surgery, and others of course. During the course of the discussions here, consideration might be given to determining whether or not it is desirable to develop more formalized requirements for training in the radiological sciences as they are of interest in these various medical specialty areas.

The whole field of postgraduate medical education is one of great concern to the American Medical Association and represents a major portion of the association's scientific and educational activities. It is in these programs that an attempt is made to help keep up-to-date the physician who has finished his medical school training, his internship, or his residency training. This type of continuing education begins where the university leaves off, or, possibly to put it more properly, it begins when the student leaves the university.

Examples here of AMA interest and concern can be found in the program of the Council on National Security which has distributed literature, conducted exhibits and symposia on the recognition and treatment of radiation injury.

Attention has also been given to the dissemination of information on the civil defense aspects of rural and urban problems of radiation protection.

Other examples of the AMA effort and interest in continuing education are the biannual scientific sessions held at the AMA's meetings and the numerous scientific publications of the association.

In order to determine what the further role and interests of the American Medical Association should be, the Board of Trustees established an ad hoc Committee on Atomic Medicine and Ionizing Radiation. This committee was charged with the responsibility of (1) identifying the problems in the broad field of atomic energy and ionizing radiation as they relate to medicine and health, and (2) attempting to list these problems in a suggested order of priority.

Under the guidance of the ad hoc committee, questionnaires were sent to 54 of the AMA constituent societies, to 101 individual outstanding scientists throughout the United States, to 106 specialty societies in medicine and related fields, to the major departments of government, and to various councils and committees within the American Medical Association. Each was asked to state their opinion as to the major problems in the field of atomic medicine and ionizing radiation as they related to medicine and health.

The responses to these letters of inquiry were tabulated and, although they have not become a formal part of the committee's report, it would not seem out of place to indicate that the two major areas of concern pointed up are as follows: (1) the need for training adequate numbers of professional and technical personnel in order to staff hospital, industrial, government, and public health programs involving the radiological sciences; and (2) the need for increased educational efforts at all levels of medical education into the basic facts of radiation, recognition of hazards, recognition and treatment of injury, and the rational medical uses of various sources of ionizing radiation.

These two findings coming out of this survey would seem to support the purposes of this Princeton meeting on curricula in radiological health.

The establishment of curricula in special and limited areas of knowledge results almost invariably in the development of specialists. The increasing number of and dependence on specialists in fields allied to medicine has made it imperative to recognize that the counterpart of specialization is cooperation. The American Medical Association has created a "Committee on Relationships of Medicine with Allied Health Professions and Services." This committee is a joint committee made up of members from the AMA Board of Trustees and the AMA Council on Medical Education and Hospitals. The guiding principles laid down by this committee recognize the interdependence of the professions, the need for each to understand the other, and the necessity for harmonious relationships. Thus this committee, in a recent report adopted at the 1960 meeting in Miami Beach of the AMA House of Delegates, recommends conference between allied professional and technical personnel and the medical profession. It is believed that these groups and the medical profession should cooperate in determining educational and training standards.

Thus, the AMA is keenly interested in the development of educational standards for all levels of medicine and for the allied professions in the field of the radiological sciences and in the development and perpetuation of good interprofessional relationship between these groups.

American College of Radiology

Dr. Wendell G. Scott: The American College of Radiology represents 5,000 radiologists in the medical, political, and socioeconomic field of radiology. It deals with the Federal health agencies in problems affecting radiology. It deals with the other organized societies of medicine. It deals with the American Hospital Association in the maintenance of radiological safety standards in the hospitals. In this aspect, the college was requested by the American Institute of Architects to assist in formulating plans and a radiological guide for the installation of equipment in hospitals.

Prominent specialists in this field were asked to cooperate and a book has now been published and widely circulated throughout the country supplying information on planning and building radiological departments in hospitals. The architects and engineers had an abundance of information on plumbing and how to set up kitchens but they didn't have information on how to set up radiological departments and provide for proper radiation protection.

The college is also very much interested in health insurance plans and in the formulation of these plans as developed by industry, in talking with the leaders of the labor unions and with officials of Blue Cross—Blue Shield and commercial insurance companies, to see that adequate radiological provisions for diagnostic and therapeutic radiology are included in these health policies.

The American College of Radiology is not a scientific organization in the sense that it supports and promotes research and investigation. These functions are carried on by three other radiological societies -- the American Roentgen Ray Society, the Radiological Society of North America, and the American Radium Society. Practically all the members of these societies are also members of the college.

The college has a sense and feeling of responsibility for the active dissemination of radiological information concerning medical problems to their own membership. This is done by a monthly newsletter which contains up-to-date information on all types of recommendations developed, standards of radiological safety as issued by the National Committee on Radiation Protection, the International Commission on Radiation Protection, the Atomic Energy Commission, and other groups. This is also accomplished by conducting an annual meeting for clinical teachers of radiology. At this conference, problems relating to education of radiologists and radiation physicists and those in allied fields are discussed and policies are developed and formulated.

The American College of Radiology has also encouraged the National Scientific Organization to include instructional and refresher courses for radiologists at their annual meetings on radiation safety, and stresses the importance of minimizing radiation exposure in the various techniques that are used in radiographic examinations as well as in the uses of radioactive materials for treatment.

In our responsibility to disseminate radiological information to the medical profession, we have been extremely busy. One of the first things that we did was to get together with the Commission on Units, Standards and Protection, of which Dr. Richard Chamberlain is chairman, and evolve a manual under his editorship on radiation hazards and their control. This is not just a "throw away" pamphlet but a booklet illustrated by various diagrams and techniques of color to incorporate all of the information available on the best means of minimizing radiation exposure and the proper use of all radiation materials used in medicine. The Rockefeller Foundation gave us a grant of $15,000 toward the preparation of this booklet. The material was approved by the genetics committee of the Committee on Biological Effects of Radiation of the American Academy of Sciences.

Additional financing was supplied by the college itself and a copy mailed free of charge to every practicing physician in the United States. The American Dental Association was very cooperative in the preparation of this book and in paying for some of the expenses of its distribution to every practicing dentist in the United States.

That was accomplished 3 years ago. Since that time, many organizations have ordered thousands of copies and it has been distributed throughout the country.

The next step then was to supply the medical profession with a visual demonstration of the things we talked about in the book, a graphic representation that they could study. We again went to the Rockefeller Foundation. The American College of Radiology had allocated $15,000 and the Rockefeller Foundation supplemented this with a grant of $65,000, for a documentary motion picture, without propaganda, expressing the opinions of top experts in the country about the various phases of medical radiology.

At that time, we obtained the cooperation and interest of the Division of Radiological Health of the U.S. Public Health Service in this problem. We could see that all of our $80,000 was going to be spent on the motion picture and we wouldn't have any money left to buy copies. They liked the idea, gave us help and advice, and we were then able to finish the project.

The picture was made by sending out the motion picture cameramen and their crew, the sound crew, the electricians, the technicians, the script girl, and the director to photograph and interview the top radiologists and scientists in the field of medical radiation. The picture equipment and the motion picture staff was moved into their laboratories, and they were invited to tell their own story. The material gathered was then brought back and reviewed. It was cut down in length and spliced into one motion picture. Everyone said what they wanted to say. The name of this film is "Radiation, Physician and Patient." It has been shown over 1,000 times to various medical groups all over the country. It can be obtained by writing directly to the American College of Radiology.

The U. S. Public Health Service bought 160 copies and gave the college 80 of them. They are distributed by the Eastman Kodak Company who does this for the American College of Radiology as a public service to the medical profession. The U. S. Public Health Service has a copy in each of its Regional offices where it can also be obtained by making direct application.

As radiologists, we also have a responsibility for disseminating information to the public. Our problem here has been to keep the information in perspective. At first there were many "scare" stories printed. They were all out of proportion, all out of perspective. This had to be overcome and a sound understanding achieved.

Recently, you are seeing more intelligent and well balanced articles about all forms of radiation in the magazines and in the newspapers. The pendulum has swung back to a middle course. Stories on radiology are now well organized and sanely written. A lot of this has been the result of the college's effort. We have supplied the writers with advice and help in this field. Dr. Richard Chamberlain, Dr. Hovey, and others among us have spent many hours with authors going over their papers before publication. We don't attempt to change the articles. We only try to help supply the facts and to direct the others to sound sources of information which ultimately become incorporated in their story.

Radiology has always had a difficult time in getting adequate time on the curriculum in any medical school. Whenever we try to get a new course in the curriculum on radiation physics or on diagnostic radiology or on radiation therapy, or on the use of radioactive isotopes, we really have to do a lot of missionary work and preparation. With radiation exposure becoming such an important subject, this task is now less formidable.

Today through our efforts and through the efforts of all you gentlemen here and the groups that you represent and the live interest in radiation, we are getting more recognition by the medical school faculty today, not only in the teaching of clinical radiology but in allied fields. You certainly have our firm support in seeking expanded educational opportunities in this field.

The American College of Radiology works closely with the Radiological Health Division of the U. S. Public Health Service. It has been a pleasant and a profitable experience for both of us. Our main problem today is to see that the American public and the American medical profession receives sound knowledge about radiation and that every means is used to keep radiation exposure to a minimum in medical practice consistent with the best quality of diagnostic procedures.

Association of American Medical Colleges

Dr. William Stone: When one attempts to speak for 85 medical schools, obviously this is difficult. This is the number of schools in this country, and I might add they are closely associated with Canadian schools as well.

If you look into health research the analysis of health happenings and the defining of health problems, a very substantial part of all that is being done is actually being conducted by the medical school faculties and students, at both the graduate and undergraduate level.

The subject of curricula is one that really strikes terror into the heart of any Dean. The length of the medical curricula today is such that it is really hard to add anything to it. All medical schools are constantly trying to shorten the curricula. I think this factor has to be borne in mind.

One encouraging thing in medical education is the series of teaching institutes by the Association of American Medical Colleges conducted over the last several years in which individual phases of the teaching program are considered. It is in these institutes that medical schools try to iron out teaching problems, exchange ideas, and attempt to delineate better ways to accomplish the teaching mission. I am sure that the subject "radiological health" will take a prominent place in future teaching institutes.

The subject of curricula is demanding the interest of all medical schools, because of the need to include new knowledge and the necessity to place limitations on lengthening a program of medical education almost beyond the individual's or the university's ability to support. For these reasons, any subject material proposed as an addition to undergraduate medical curricula receives careful scrutiny to determine if inclusion is justified. Most medical schools only attempt to make the undergraduate medical student aware of radiological health. Definitive teaching of this subject is reserved for graduate and postgraduate programs.

In most schools there is a special effort made to arouse the interest of undergraduates in radiological health, particularly those with the opportunity to take additional basic science work such as the post-sophomore programs which may lead to a Ph.D. degree. However, in the regular curriculum itself, the staff of most school faculties believes a formal program in radiological health cannot be presented.

It can be safely stated, however, that all medical schools are very much interested in the subject and that they are using, in a major way, ionizing radiation in diagnostic, therapeutic, and research work. Because of the influence of ionizing radiation on all living things, radiobiology in its various aspects is being taught at all levels in the medical school curricula integrated with other subjects. In some medical schools, elective courses are offered on this subject.

There is a great appreciation by medical school faculty of the short and long term influence of ionizing radiation on health. They are very much aware of the possibility of radioactive isotopes from various sources contaminating food, water, and air. As far as I can determine, most medical schools do not devote a portion of the curricula time to a specific treatment of radiation health. They integrate the teaching of radiobiology in the Departments of Microbiology, Pathology, Radiology, Biophysics, and Preventive Medicine with special presentations in such fields as genetics, hematology, cancer therapy, and biochemistry.

For many, there is still a question on the effectiveness of teaching a subject like radiological health as a separate course, in the undergraduate medical school curricula. The medical schools currently have had the benefit of a U. S. Public Health

Service-sponsored survey by Dr. David A. Wood and Dr. Peter G. Loret at the University of California on teaching the subject of cancer in medical schools. The schools were divided roughly into two groups, those that teach cancer as a special subject and those that integrate the teaching of cancer into the various departments of the medical school.

At the end of the sophomore and the senior year, a comprehensive examination was given and graded objectively by test standards. The effectiveness of the teaching methods were then analyzed. This particular study revealed clearly that students at an undergraduate level did better in those schools that did not create a special course in this subject.

There are various reasons expounded as to why this is true, but one held by many is that if you relieve the departmental faculty from the responsibility of presenting their subject adequately with the thought that someone else will do part of it, you will not get as good a coverage of the subject. From this it would appear that there is something to be said for closely associating the teaching of related subjects with the subject being taught.

There is a feeling which is now largely shared by all medical schools that the medical aspects of disaster training should be in the teaching program, in view of our national defense responsibilities. This program has the backing of the Armed Forces, the Public Health Service, and Civil Defense, with small financial support for coordinators and for faculty to attend symposia and to invite speakers. This particular program is called the MEND program -- Medical Education for National Defense. Radiological health plays a rather prominent part in it, and there is an attempt to indoctrinate every medical graduate with at least some basic information on radiation injury, how to prevent it, how to judge it, and triage patients at a treatable level and unresponsive to treatment.

There are some 40-odd medical schools participating in MEND at the present time and it is expected that by the end of this year that the number will be in the 60's. It is hoped that all schools will participate ultimately in the studies. The faculty of the individual medical school is given the opportunity to visit all of the nuclear installations, including those of AEC, that are involved in radiation studies and there is a real attempt made to keep the faculty oriented.

The Association of American Medical Colleges is increasingly aware of the need for emphasis on radiological health in medical schools and I am sure it will not only cooperate with any move to improve the teaching of the subject in university curricula but will continue to make important contributions in the development of understanding by the physician and the public of how ionizing radiation influences health and how injury can be prevented and how it can be treated.

American Public Health Association

Dr. James L. Troupin: The storehouse of knowledge in radiological health has grown, through constant and active research, to appreciable proportions in recent years, and the interests of the American Public Health Association (APHA) lie in the direction of bringing this knowledge to the place where it can be put to work for the public good.

The association's public health policy on radiological health was published in the June 1960 issue of the American Journal of Public Health. It stresses basic public health objectives, which are to recognize the essential uses of radiation and to reduce, wherever possible, exposures incident to them, as well as to preclude unnecessary radiation exposures. In other words, the association is deeply concerned with bringing a realization of the problem before public health workers and with helping them to understand the implications of ionizing radiation in a personal, psychological, and social environment. Let us consider a few channels through which these goals may be attained.

The publication of printed material is recognized as an important method of disseminating information. The APHA's Program Area Committee on Radiological Health has produced several examples in this field. One such booklet is entitled "Public Exposure to Ionizing Radiations" (subtitle: "What Public Health Personnel Need to Know"). This booklet introduces a few elementary ideas about radiological public health, with the tone of the publication remaining practical throughout. A minimum of scientific background is required for the public health worker to understand its message, and a useful glossary of terms is included.

Another pamphlet is entitled, "Radiologic Health Practice," — with a subtitle, "A Guide for Public Health Administrators." Here the stress is on the organization of a radiologic health program and the control of ionizing radiation wherever used in a community. A valuable bibliography is included.

While these and other pamphlets may serve to provide useful material for public health workers, their existence does not guarantee that the persons who should read them will do so. A more effective method of dissemination of knowledge is the bringing together, even for a short meeting, those persons to whom such knowledge is deemed to be essential. In this way, fundamental concepts can be presented and implications for the health of the people can be emphasized. Public health methods as related to ionizing radiation and examples of practical application can best be put across in such face-to-face meetings. While APHA cannot, for obvious reasons, undertake to sponsor continuation education courses, it tries to stimulate and promote the establishment of such programs under other auspices.

It is true that many continuation education or postgraduate courses in radiation undoubtedly will be conducted within a university environment but this is not the only resource available for the implementation of such a program.

I should like to mention one other method of bringing new knowledge and new viewpoints to public health workers already in the field in their jobs. Many State health departments conduct periodic conferences for their public health workers, bringing these persons together for a 2 or 3 day session. While generally not labeled as such, these sessions may be considered as postgraduate education since problems of public health and methods for solving them are discussed. If a State health department were to devote a day or two, either at the time of its annual conference or on another occasion, to problems of radiological health, a large step would thus be taken in making more widespread an awareness of principles and programs in this important field. Faculty members could be obtained from universities. The problem of adequate funds may be solved, at least initially, by the diversion of some of a State's training funds to the cause of postgraduate education.

In addition to postgraduate education in radiological health for the experienced public health worker, some attention should also be given to the new public health worker -- the one who is currently receiving his training. Schools of public health have offered instruction in radiological health to their graduate students for several years. In a partial summary of subjects taught by faculty members for the academic year 1959-60, 8 of the 13 schools in the United States and Canada report a total of 14 teachers in radiologic health. We know that a few years ago there were few, if any, such teachers.

While the teacher in radiologic health undoubtedly concentrates on the graduate student who is specializing in this field, the number of such students is as yet relatively small. In the 13 schools of public health, 11 graduate students were so registered in 1958-59. In the year 1959-60, there were 25 students majoring in radiation health. I am not going to attempt to project into the future!

With growing emphasis on this subject, schools will employ more teachers and will matriculate more students. One of the problems, therefore, which lies before us involves systematizing academic training in radiation health. This does not mean the imposition of a kind of uniformity on all schools but rather it implies the formulation of minimum standards. This task will undoubtedly be undertaken by APHA in conjunction with the Association of Schools of Public Health, and with technical advice from other groups. Some steps were already taken in this direction by the World Health Organization with their publication on training in radiologic health for public health workers.

We should now turn our attention away from the student who is specializing in radiation health and focus for a moment or two on other graduate students in public health, including educators, engineers, sanitarians, and a number of others. Survey courses in radiation health at varying levels of intensity should be part of the standard curriculum in every school of public health, so that public health workers of all categories and in whatever branch of specialization can have at least a minimum acquaintance with radiologic health and can understand its implications for the total health of the people.

In these days of anxiety about ionizing radiation, every public health worker, whether nurse, health educator, or other, stands in a particular relationship with the citizens and is regarded as an authentic source of information regarding health problems. Now that ionizing radiation is becoming one of our important health problems, it is unwise to permit public health workers to remain in ignorance of the facts.

Thus we can summarize that the interest of the American Public Health Association is to bring increased knowledge to all public health workers, so that they may be more valuable and effective servants of the public.

Technician Training

Dr. Lewis R. Fibel: There is no need for me to elaborate before a group of this sort the sure fact that the atomic industries, the application of radioactive isotopes to industry, and the use of isotopes and other radiation in health and other services is going to expand greatly in the next years. Nor is there any need to stress the fact that personnel will be needed to deal with all phases of the research, design, production, handling, and use of these radiation sources.

Perhaps, however, it is a good idea to repeat the kinds of personnel problems that may result. It is apparent to me that many people who have already been trained or educated will need retraining in the use of these new instruments and devices. It is also true that students in the conventional fields, for example, of chemical and mechanical engineering, will in the future have included in their curricula information about radiation, its hazards, its uses, its control. I want to return to this topic later as it relates particularly to the training of technicians.

It also is quite obvious from what has been said today that there will be a need in coming years to educate certain people in new and more specialized fields, in nuclear engineering and in health physics, among others.

The main point I would like to make at the outset of my talk, however, is that it will not be sufficient merely to train professional personnel. It will also be necessary to supply these people with qualified support personnel. In radiological health alone, you have heard the figures of 4,000 support personnel required compared to 1,200 professionals. I want to talk about the 4,000.

The idea of a team in a technology, of professionals assisted by support personnel, can be readily understood in terms of the conventional field of medicine where such practices are fairly long-standing. Today the physician is the main professional person in medicine but he is assisted by, and in fact would be almost helpless without, the support of nurses, medical laboratory assistants, X-ray technicians, medical secretaries, dieticians, pharmacists, and a whole host of other supporting personnel.

The training program that these people receive is of necessity and should be less in length and in breadth than that given to the professional. The regulation of the field of medicine by law has required the fairly rigid definition of the role of the physician as well as the role of supporting personnel. Furthermore, the type of education required for all of these roles has been rather rigidly defined.

The same is not true today in the fields of science and engineering. It may be that as we are coming to increased legal control of radiation hazards, there will also come into being increased legal definition of the type of persons required to carry out control functions, and their educational requirements will also be specified by law. Perhaps a start in this direction can be recognized in the formalization of the civil service job classification in this area.

At our college, the New York City Community College, we have been engaged for some time in discussions on the organization of a collegiate curriculum, 2 years in length, specifically designed to train technicians in the field of nuclear education (see p.). We visualize at least three distinct, specific subdivisions in this general field: first, nuclear power; second, radioisotope use; and third, monitoring and health physics.

We have designed a curriculum with common areas in these three fields, the common area being in the first year and specialization taking place in the second year. Our proposed program consists of a core of English, social science, mathematics, and science, common to all curricula, with specialized work in various phases of nuclear technology and techniques.

The options differ in the nature of the technical courses required. I don't want to bore you with a recital of a list of courses or a list of topics within these courses, but these have been devised and are available, not only the work that we have done but the work that other institutions have done.

Other colleges and other organizations have also shown interest in this work but I don't believe there has been much accomplishment as yet. Some of the developments of which I am aware, and there probably are many more, include the inauguration of a course in the training of nuclear technicians by Pensacola Junior College in Florida this coming fall. Los Angeles Trade Technical College is offering courses in the application of radioisotopes to industry and in radiation safety, and Montgomery Junior College in Maryland plans inauguration of a course for radiological health technicians.

Both the Atomic Energy Commission and the Division of Radiological Health of the U. S. Public Health Service have indicated great interest and have been encouraging 2-year colleges to establish this kind of training.

I don't know how many of you are aware of the comparatively new development in this field of education covered by the general term -- technical institute. The technical institute, although historically not a novelty, has only come into real fruition in the years following World War II. The technical institute program is generally a 2-year post-high school program which is designed to train technicians for specific engineering or scientific fields. Among these fields are electrical, mechanical, civil or construction, chemical, automotive, and other technologies. These programs are offered in various institutions, either in those that are designated as Technical Institutes, (for example the RCA Institute in New York City which offers training in the electrical field), or in community or junior colleges, which are usually 2-year colleges. Examples of this are the New York City Community College and the Montgomery Junior College, which I have mentioned, and the very numerous junior colleges of the State of California, where the movement has grown tremendously.

There are altogether some 600-odd junior or community colleges in the United States, compared with about 1,800 4-year colleges. The proportion of college students enrolled in junior colleges has increased steadily as compared to the number enrolled in the 4-year colleges in the last 10 years.

Technical institute programs are also given in 4-year colleges. The Pennsylvania State University with its various branches throughout the State of Pennsylvania is a good example of this type of operation. The same thing is true in Wisconsin and in other States. Programs of this sort are also given in professional schools, for example some of the medical colleges in New York offer 2-year programs of this sort. I don't make any particular distinction between these kinds of institutions. I use the words "technical institute" as generic for all of them.

Community colleges (and I use a different term now -- we always seem to run into nomenclature difficulties) offer three kinds of programs, all of which I think are of potential interest in radiological health.

First: university parallel work or transfer programs are offered which are the general equivalent of the first 2 years of the baccalaureate program, since the student intends after 2 years at the community college to transfer to another institution and complete there the requirements for a bachelor's degree.

Second: terminal courses are offered of the "technical institute" type that I have just mentioned. In this program the graduate is prepared at the end of the 2-year period to assume a responsible job in industry at the technician level.

Third: the program offered is the short course or extension program for specific training in a particular technique or a particular industry or perhaps even for a particular company. This last, I think, has much application for the retraining of people.

Although terminal programs are intended to train for immediate employment, this is not always the intention or does not always remain the intention of the student enrolled in such a program. He may wish to transfer to a 4-year institution and go on to the baccalaureate or even higher degrees. Many of our graduates of terminal programs do this. In the design of curricula for technical institutes, we try to keep in our mind that some of our graduates will make such transfer.

Some mention should be made of the term "technician" and its implications. To be candid, the term "technician" is sometimes used in a derogatory sense and I am sure that you are all familiar with the phrase "a mere technician." The term can also be used in a praiseworthy sense. When we say that Mischa Elman is a "superb technician," there is certainly nothing derogatory about that. In the educational jargon that has grown up in the technical institute movement, we have seized upon the term "technician" to describe our product. We are not completely happy with it but it probably has more meaning than any other term. We mean by this a person who has been trained to do a semi-professional, or if you like, a sub-professional job. He is generally one who assists the engineer or the scientist. He may be expected to have some mechanical skills, but not as much as the craftsman; some theoretical knowledge, but certainly not as much as the engineer or scientist.

Again parallels can readily be made in other fields. Most of us are acquainted with the role of the dental hygienist in assisting the dentist. This we consider a technician role. If I may go out on a small limb, it is my feeling that a nurse who assists the physician is a technician (my wife who was a nurse disagrees with this). In a similar way, the engineering technician assists the engineer, the scientific-technician assists the scientist. And it is our belief that there is a very definite role for nuclear technicians to aid the nuclear-scientist, the nuclear-engineer, and the radiological health specialist.

Undoubtedly, there are many levels of technicians and unless there is some legal restriction on the use of the term it probably will continue to exist. I remember seeing an announcement recently of a course at Oak Ridge for atomic technicians which required a Ph.D. degree for admission.

One may justifiably inquire where we are going to get the people to enroll in technician programs, if engineering enrollments are falling off. This is a fair question and certainly deserves a fair answer. Our experience has been that the sources of people for these programs are essentially three. First are persons who prefer 2 years of higher education. This group is composed largely of women who wish to complete the education necessary for gainful employment in as short a period of time as possible so that they can get out on the labor market and start earning money. These women usually get married shortly after they start working and when they start bearing children are removed from the labor market in any event. Our experience has been that they have on the average 5 years of useful work after graduation from a 2-year program. The advantages to the individual and to industry of such people over the 4-year graduate of the same sort are, I think, obvious. And it has been our experience, and perhaps many of you can confirm this, that women are extremely well-qualified for many laboratory technician jobs. They perform routine but painstaking operations carefully and without complaint, and you can't always say the same thing for men.

The second source of people for technician programs is those who cannot afford a 4-year college. Many of these will, we find, complete their 2-year program, go to work as a technician during the daytime, and continue or attempt to continue their education in the evening on a part-time basis. These people, too, usually make excellent technicians and have again an average of 5 years of useful technician work.

The third source of applicants for such programs, and perhaps the largest, are those people who frankly are not academically or intellectually qualified to do the work of 4-year programs, especially not the rigorous mathematical and theoretical abstract work that is required for programs in science and engineering. There are problems in getting people of this sort to realize their limitations and to enroll in technician programs instead of baccalaureate programs. I would not minimize this difficulty for one moment. The high school guidance counselors have not gotten the word as yet, and are not advising students with I.Q.'s of 115 but with a definite interest in science, that they might do much better and be much happier to enroll in technician programs rather than in baccalaureate ones.

But it is our feeling that as these fields become better known, as the colleges that offer these programs become better known, that there will be an increase in the number of applicants. Our experience at the present time is that we get four applicants for each opening we have in such programs at our college.

The principal justification in the training of a specific technician class is that these people can do some levels of work better than professionals and more cheaply. Further, they are more competent than the untrained high school graduate. However, there is always a manpower utilization problem; the most economic combination of professionals, trained technicians, and untrained personnel has to be determined for each situation and it is never identical in two.

I would like to return briefly to a point which I touched on earlier — the question of generalization versus specialization. This is a problem that is faced by the engineering colleges and by many other educational institutions, as well as by the technical institute. It seems to me that the technical institute has a responsibility to train a person specifically enough so that he can find a job upon graduation, but, on the other hand, to train him generally enough so that if the particular job is curtailed or discontinued, he can find a job in a relatively closely allied field.

The whole question of nuclear engineering has been under discussion for some time. The consensus but not of course the universal opinion is that this is best restricted to the graduate field, and that undergraduates in mechanical, electrical, or chemical engineering should have sufficient material about nuclear energy in the curricula to enable them to work in nuclear industries, but that it was best for them not to specialize on an undergraduate level. This is pretty much my view with regard to technician training. I feel that a large number of the potential technician jobs in the nuclear industry can be handled well by our present trained chemical, electrical, mechanical, or medical laboratory technicians, if they are given in their regular curriculum some training in radioactivity — its measurements, its controls, its hazards, and so forth.

This has been our approach. We are including as a part of our regular curriculum in chemistry, for instance, the study of radioactivity and its effects, and the Atomic Energy Commission and its local offices has been quite willing to hire some of our product. We also are inaugurating in our extension division, special courses in radioactivity measurements which will be given both for technicians already out on the job and for any of our present evening division students.

I would like to make one final statement about the role of 2-year colleges in relation to radiological health that has been made with regard to other programs today. All persons who are studying at 2-year colleges should have some knowledge of radioactivity, its hazards and its controls, from a general point of view. The educated citizen today and especially in the future is going to be required to make decisions about political and other matters that will require some knowledge of radioactivity, what it can do, and what we can do with it. I think, therefore, that we should give serious consideration to the inclusion of material of this sort in our sociology courses, in our health education courses, and in our physics courses, for all students.

In summary the 2-year colleges have the following functions which they can, and I believe they will, play in this field: First, to train technicians for nuclear power applications, for laboratory work with radioisotopes, and for monitoring and health surveys; second, to incorporate training in radioactivity measurements and uses in their present technician programs; and third, to educate all of the students in their colleges in the implications of nuclear energy and the hazards of radiation.

I would like to emphasize that the rate of development of programs of this sort in 2-year colleges will be proportional to the pressure put on the colleges by interested persons. These 2-year college facilities are limited, just as are other higher educational facilities, and many groups have special interests along these lines that they are trying to promote, so if you think this area is important, if you think there is a potential in this kind of program, you will have to take the lead in its promotion.

Short Course Training Program

Dr. Dade W. Moeller: My remarks will be limited to the short-term technical program sponsored by the Division of Radiological Health and conducted at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio.

The Robert A. Taft Sanitary Engineering Center is one of the national laboratories operated by the U. S. Public Health Service and is the principal facility in which engineering research activities are conducted.

The program of the center is divided into five principal areas, four of which deal with research on air, water, food, and radiation. All of these relate to the environment and the problems of environmental health.

The fifth area deals with training, a program by which the center attempts to make known and available the benefits of these and other research findings principally to State and local health department personnel. The Division of Radiological Health operates the radiation research activities conducted at the center, and a significant portion of the total training program.

The work of the training program is conducted in permanent facilities located at the center. For the courses on radiological health, these include two counting rooms and a radiochemistry laboratory.

The training program benefits, of course, from our immediate association with the people in the four research areas, whom we call upon as guest lecturers. Among the trainees and participants in our courses are personnel from industry, from universities, and from State and local health departments, many of whom in turn serve as consultants to us and feed back information into the training program. We believe that through the training program we maintain valuable liaison with many operating groups.

Courses sponsored by the Division of Radiological Health are divided into three broad areas: health physics and instrumentation, the medical aspects, and environmental surveillance.

In the health physics and instrumentation phase, we offer a series of four courses. Additional courses for this series are planned for a future date.

"Basic Radiological Health" is a 2-week program dealing with fundamentals of radiation. In this course we also cover basic atomic and nuclear physics and the units and nomenclature associated with radiological health, and we acquaint the trainee with the basic instrumentation that he will utilize if he works in the field or laboratory. Because of our extensive counting equipment, some $100,000 worth, we hold a laboratory session every afternoon, following the morning lectures.

Prerequisite to the basic course, and to all courses offered at the center, is the bachelor's degree. When a trainee has completed the basic course, which, incidentally, we believe the colleges should offer so that we will not be involved in this aspect of training, he can go on to three more advanced courses. One is concerned with radionuclide protection which deals simply with proper and safe handling of radioactive materials. Or he can take a course in X-ray protection, which deals with the inspection of medical and industrial units, or a course on reactor hazards evaluation, a 2-week program dealing with problems involved in construction, site selection, and operation of the nuclear reactor.

In the second week of the course on reactor hazards evaluation, we have the cooperation of Dr. E. E. Anderson and her group at the Oak Ridge National Laboratory and the use of the laboratory facilities.

We see a need for a course on instrumentation on radiological health because of the many problems involved in the maintenance, calibration, and operation of nuclear counting equipment. We also see a need for a course dealing with peacetime emergencies. We have to proceed in these two areas within the near future.

The medical aspects are the concern of a 2-week program, set up principally for practicing physicians or physicians with public health or industrial responsibilities. Here we stress peacetime effects of radiation, such as carcinogenesis, life-span shortening, leukemia, and long-term chronic effects. We offer a short program on dental radiological health, directed toward the dentist, and this year, for the first time, we are offering a 2-week program on the nursing aspects of radiological health and a 1-week program on radiological health for X-ray technicians.

In courses on radiation surveillance, we deal with monitoring for radioactive materials in the environment, such as gross and specific measurements of radioactive pollutants in air, gross measurements of radioactive pollutants in water, and determinations of specific individual nuclides in water. A 2-week course is given also on the measurement, analysis, and sampling procedures for identifying specific radionuclides in milk and other foods.

We also present a 1-week general surveillance course to acquaint personnel in State and local health departments with the overall problem of surveying the environment for radioactive materials.

Last but not least, a 2-week presentation is offered on the "Sanitary Engineering Aspects of Nuclear Energy." This is a broad-brush course for persons in administrative or executive capacities in Federal, State, and local health departments, who have wide responsibilities in the field but who do not necessarily need to be acquainted with details.

What are the types of individuals necessary to carry on a program of this nature? On the staff of the radiological health training unit at the Sanitary Engineering Center, we have physicists and health physicists, our health physicists coming principally from Dr. Anderson's ORNL program. We also have a radiobiologist and a physician, with a dentist on call from the Division of Radiological Health in Washington. We recently added a pharmacist and a nurse. In environmental surveillance, we have sanitary engineers, nuclear engineers, and radiochemists. We also, of course, have our electronics specialist. These professionals conduct our training courses.

Where do the trainees come from? During the past 12 months, about 500 people have taken the courses conducted by the Division of Radiological Health. Some 19 percent came from State and local health departments, 4 percent from other State and local agencies, 31 percent came from within the Public Health Service itself, 22 percent came from other Federal agencies, including the AEC, the Tennessee Valley Authority, Food and Drug Administration, Department of Agriculture, and the military services. Nine percent were visitors from foreign countries, some 4 percent were university faculty, with 11 percent from industry. Other categories make up less than 1 percent of the total.

Training in radiological health education is one of our special activities. The need for educating the public in this field is well known. At the instigation of Training Branch leaders in Washington, we gave a special course last year for health educators from State health departments. The participation was outstanding. As a result of this course, five States devoted sectional meetings of the American Public Health Association to radiological health. We plan to present this same course again in January 1961.

Another special activity is our Summer Training Institutes. Two years ago, on the campus of the University of California in Berkeley, we presented our 2-week course on "Sanitary Engineering Aspects of Nuclear Energy." Last summer, at the University of Massachusetts in Amherst, we presented our "Basic Radiological Health" course. This past month, we presented "Environmental Surveillance" at Florida State University in Tallahassee. It is our aim to present a series of courses at a selected university each summer, in cooperation with the university staff and the State health department, for the benefit of regional personnel unable to come to Cincinnati.

Other special activities include development of training aids. For each of the courses described, a manual containing sentence outlines of all lecture and laboratory sessions is prepared. Those of you interested in these manuals may obtain reference copies upon request.

Available also is a film library containing some 25 films which we have selected as having specific interest and value in radiological health.

We want to encourage you in every way possible to use our training facilities and also to stimulate this type of training. We feel that we should not be presenting the basic course but, in this particular field, we are required to give our trainees the fundamental knowledge and capabilities which are necessary for more advanced training.

If the universities present some of these basic courses, we feel that we can then devote our training efforts to our true objective of bridging the gap between the acquisition of new knowledge and its application in the field.

Schools of Public Health

Dr. James A. Crabtree, Dean, Graduate School of Public Health, University of Pittsburgh, Chairman.

Dr. Russell H. Morgan: With the emergence of radiological health as a public health discipline, schools of public health should turn their attention to the curricula whereby men interested in the field may gain the knowledge necessary for them to become effective leaders in government, in industry, and in the health professions.

The curricula in radiological health that is to be developed in any school will be influenced by a number of factors. Among these may be included the background of students admitted to the program, the background of the faculty, the needs of those agencies and institutions who seek graduates from the program, and the funds available for program development.

The students currently entering the field of radiological health come from a wide variety of backgrounds.

Some of them are graduates of engineering schools, others have a background in biology, some in chemistry, and still others are graduates of medicine.

It is not surprising, in view of this broad cross-section of interests, that many of them have deficiencies in one or more of the prerequisites needed for a sound educational program in radiological health. And when the curricula for radiological health are formulated, these deficiencies must be recognized and adequate provision made for the student to fill in those portions of his education where gaps exist.

Another factor which determines curricula development is the breadth of interest of the faculty in radiological science. If it is composed principally of men with a background in engineering, the curriculum is likely to be slanted in the direction of nuclear science. If it includes men whose interests fall primarily in the basic sciences, the curriculum is likely to be strong in the disciplines of radiobiology and radiation physics. However, if such is the case, it is likely to be weak in the disciplines of health physics and sanitary engineering. And if the faculty is composed principally of men with backgrounds in medicine, the curriculum is likely to be strong in radiation protection and safety in the medical field and deficient in the engineering branches.

Since strength in all of these disciplines is important for the success of any program in radiological health, care must be exercised in the selection of the faculty, in order that all of these disciplines may be properly represented. To supply such a wide diversity of people, incidentally, poses a not inconsiderable problem for many schools of public health.

The interests of the agencies and institutions seeking graduates also may be expected to have an influence upon curriculum. Over the next decade, industry, including perhaps particularly the facilities of the Atomic Energy Commission, and public health agencies may be expected to demand the greatest number of graduates of radiological health programs in this country. I think that the estimates made yesterday by Jim Terrill focus on this pretty sharply.

Although the responsibilities placed upon the industrial radiation health specialists are likely to be quite different from the duties of those employed in the field of public health, I believe it is important that the industrial radiation specialists and public health men have as comprehensive

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a background in all radiological health disciplines as possible, even though engineering responsibilities for the industrial men may outnumber those in the biological field to a major degree and vice versa for the public health men.

The need for vaster training on a broad scale for a public health worker requires no emphasis. He is required to be conversant with engineering and biological problems alike and it seems desirable that curricula for radiation health specialists in schools of public health be of a broad, comprehensive nature, even though certain of the agencies and institutions which graduate students may have a more limited requirement.

One of the major items affecting curriculum is the amount of money available for program development. I cited some of the thoughts on this yesterday. A substantial reduction in the cost of operating a radiation health program in a school of public health can be effected by a reduction in the number of laboratory exercises required of the students, since most of the cost, or a large part of them, is involved in heavy expenditures for instrumentation. However, I feel that if a university finds that its funds are so limited that reduction in operating costs is necessary, it is probably better not to embark upon a radiological health program at all than to do so with only limited laboratory experience being made available to the students.

It is difficult to make general rules concerning the ratio of didactic or seminary hours to laboratory hours, but it has been my experience that the ratio should be not less than two laboratory sessions per didactic or seminary session. It is better to have a ratio closer to three to one.

The needs for radiation health specialists in this country appear to be such that two types of individual are required. The first is a highly qualified man who has received 2 or 3 years training at the postgraduate level and has been granted a doctorate in one of the radiological sciences, and who is able to supply leadership in the development of radiological health programs in the various technical areas of society where such service is required. The second type of radiation health specialist is one who has not reached such high academic and intellectual standards, but instead has received 1 or perhaps 2 years of postgraduate training in radiological science, has been granted a master's degree for his work, and who is able to occupy a position of considerable responsibility at the operational level, including the supervision of nonprofessional technical people.

The need for two types of radiation health specialists, one educated to the doctorate level and other to the master's level, makes it appear that the schools of public health must consider two types of curriculum in the field of radiological health. It is interesting to note that the same conclusion has been reached recently by the Committee on Training in Radiological Health and Safety of the United Kingdom Atomic Energy Authority, or the so-called Veale Report.

Let us, therefore, examine the program content of a suitable curriculum in radiological health, first at the master's level and then at the doctor's level.

In both cases, a number of introductory courses are needed to bring the students with widely varied background to a common denominator.

These introductory courses should include one or more of such biological subjects as general biology, zoology, botany, genetics, such courses in physics as general physics and atomic physics, and such courses in chemistry as physical chemistry and biochemistry. I have mentioned only a few.

When students are brought into a school of public health and it is found that one or more of these introductory courses must be completed before he or she is ready for basic and applied work in radiological science, one is frequently faced with the problem of how to best schedule this introductory work. It is usually inconvenient and costly for a university to have such introductory courses given within the Department of Radiological Health itself and conflicts frequently arise between the time required for these introductory courses by other departments and the time required for courses in radiological health.

I know of no way to get around this problem too satisfactorily. However, I might say that we are coming quickly to the point where we believe the best solution is one in which the deficient student enrolls for the summer session at the university and works out his deficient prerequisites before the fall term begins.

The curriculum in radiological health proper may be divided into three portions, perhaps. But here again, a formal presentation seems somewhat inflexible. I think that at this stage of development, flexibility is one of the things which must be borne in mind in curriculum development. However, for purposes of discussion I have divided the curriculum into three portions. The first includes the required subjects in radiological health itself. The second portion includes those nonradiological subjects which the university requires the student to complete for a degree. And the third part includes a number of both radiological and nonradiological subjects which the student elects, to broaden his knowledge.

In our university, the required courses are similar for both master's and doctorate candidates alike (see p. 111). In the field of radiological health are included courses in radiation physics, radiobiology, radiation chemistry, and health physics. Each is one quarter in length with 9 weeks per quarter, and each calls for the student to be present for 3 lectures or seminar hours per week and 9 or 12 laboratory hours per week.

The nonradiological science courses, which the student must complete, include a one quarter course in environmental medicine. This course gives intensive work in industrial toxicology and sanitary engineering and introductory work in radiological health. Other required courses include a one quarter course in public health administration.

I'm not trying to imply that this is good. As a matter of fact, there are people on our faculty who extend, in their thoughts, all the way from those who think that no required courses should be demanded of the students to those who think there should be many more than I have indicated. This, as in most schools, represents a compromise between two ends of the spectrum.

A broad range of course material is available on an elective basis for the students. Among the courses of interest for the radiation health specialist are radiation control aspects of public health administration, mathematics and genetics especially directed toward the radiation field, physical chemistry, as well as work in radio-epidemiology, sanitary engineering, and environmental medicine. These courses are available in the School of Hygiene and Public Health. In the basic science area of the university, courses in nuclear chemistry, nuclear physics, and biophysics are a few among a great many courses which the student has available to him.

Reference has been made already to the necessity for a high ratio of laboratory to didactic or seminar experience in the curriculum for radiological health.

Another important requirement is that the postgraduate student seeking a master's degree prepare a dissertation on some aspect of radiological health and that the doctorate candidate conduct research and prepare a thesis thereon satisfactory to the faculty. In our institution, the conduct of research, plus the preparation of a thesis, plus the availability of more time to pursue elective work, distinguishes the doctoral program from the master's program.

In both cases, it is a requirement that the student prepare a dissertation or conduct research — to intensify the work which the student performs during his program.

The work included in the several required courses in radiological science encompasses the following material: In radiation physics, the student is taken through the fundamental aspects of atomic physics and radiation production, the types of radiation sources, the interaction of radiation with matter, and the physical action of radiation dosimetry.

In radiobiology, the discussion centers on the biological effects of radiation of the macro-molecular cellular organ and total organism level.

In radiation chemistry, the student is instructed in techniques wherein gaseous, fluid, and solid materials may be subjected to qualitative and quantitative assay for radioactive materials.

In both radiation chemistry and radiation physics, considerable time is spent on discussions and laboratory exercises pertaining to the instrumentational aspects of the subject.

In health physics, the student's attention is directed toward practical problems involved in radiation, radiological science as a whole, and radiological health in particular. The subject material is augmented by numerous field exercises in which the student is called upon first, to survey medical X-ray installations, and second, to become familiar with practical health physics problems posed at nuclear reactor sites.

Like most schools of public health, we are in the process of curriculum development and faculty assembly. We recognize that many gaps exist. We believe, however, that the program embodies many of the basic principles important to the success of a radiological training program in a school of public health (see p. 111).

Robertson Augustine: At the University of Michigan, we've had a basic radiological health course for approximately 10 years (see p. 114). During the past 3 years, we have developed a formal radiological health program, leading, in some cases, to an advanced degree in radiological health.

I think we can classify our program into four groups. This would correspond to the category of students we are training. First of all, we have the students who are taking merely a one semester course in radiological health. This would be the person who is not majoring in radiological health but would like a little knowledge in this field, who would like to know a little more than he gets from reading the papers. This is a survey course, one semester in length, and is called a service course -- serving other departments on campus. Usually the students are sanitarians, sanitary engineers, environmental health specialists, and some from health education. Students from assorted fields such as zoology, pharmacy, and even psychologists may take the basic course in radiological health and we get a few physicians and doctors of veterinary medicine. Also, we may have what we call a "special" student from industry — a student who comes only to take the course in radiological health.

We have approximately 30 students a year; we give this course on a semester system twice a year, once each semester, with about 15 students in each class.

Another type of program we offer is what we call the 1 year program. This is more intensive and the students are usually fellowship students, supported either by the Atomic Energy Commission, the Public Health Service traineeships, or State health departments. Quite a number of foreign students also take the 1 year radiological health program under the sponsorship of the International Cooperation Administration.

Such students as these, who are only in school for 1 year, usually are not eligible for a master of public health degree because of other requirements for eligibility and they do not have enough time in the 1 year to complete the basic public health courses in addition to intensive radiological health training. It is possible, however, for some of the more well-qualified students to complete the requirements for a master of public health degree in 1 year of study.

The two semesters of school in this 1 year program for fellowship students sponsored by these agencies usually is supplemented by a summer session spent at one of the AEC laboratories, as Dr. Anderson explained.

We have approximately 10 to 12 students a year in the 1 year program. A few of these stay for a second year, a very small number as usually there is not support for the second year of study. Those who stay over for the 2 year program have a chance to complete the basic public health courses, take more radiological health courses, and broaden their knowledge in other areas -- industrial hygiene, sanitary engineering, biology, nuclear engineering, and so on.

Also in the 2 year program, we try to encourage some independent research work. We have faith in research and if we can encourage students to do even a small research project, we feel that he learns just through the trials and the troubles of trying to accomplish something in the laboratory.

We give a good deal of practical experience in health physics — what you might call applied health physics. The students spend some time at the reactor with the health physics group; at the hospital, with the nuclear medicine and radiation therapy group; and they spend a good deal of time with the radiation control service of the university. This is our campus health physics organization, and we encourage the students to spend as much time as possible with these groups — to actually get their hands dirty and their feet wet in health physics.

Another category of student is the doctoral candidate. The doctoral program has been in existence for about the same time, 3 years.

In the doctoral program, the student is expected to complete most of the radiological health courses and all of the necessary courses which might lead directly or indirectly to his field of research. The doctoral student does not necessarily have to complete the requirements for the master of public health degree although this is encouraged as a way of broadening his overall educational program.

The doctoral student is also given an opportunity to participate in some practical applied health physics problems, some of which are problems of outside organizations that look to the university for help.

Doctoral students also participate in the teaching program. We believe that this is an important part of the training of a person at the Ph.D. level — that he not only know the material and can work problems but can convey his knowledge to other people, in teaching and in discussion.

The doctoral program usually requires 2 to 3 years of study, depending, of course, upon the man's background and whether or not he is going to take the work for a master of public health degree.

We sometimes have one other group of students in what we call our special short courses. Frequently we give a 1 or 2 week course for a selected group of people. An example might be a course in analysis of water and sewage for radioactivity for operators of water treatment and sewage treatment plants.

We might examine the relative degrees of proficiency achieved by students in each one of these four programs in relation to a professional health physics level and a technician level.

Students who take the one semester course in radiological health know the basic fundamentals; they know basic nuclear physics and atomic physics. They are able to discuss the field of radiological health fairly intelligently and perhaps carry on some minor research programs. But they definitely are not health physicists. I think that you will all agree that one course does not make anybody a health physicist.

Unfortunately, a large number of people who take the one semester course in basic radiological health -- particularly if they happen to be associated with a State or local health department -- may go back home and be the only person who has had any formal radiological health training, consequently becoming the State or local expert in radiological health. For this reason, even though we do not call these people health physicists, they should have a very good course until we can improve the manpower situation in health physics to the point where there are enough professional health physicists and it is not necessary to use a man with a limited amount of training.

Students in the 1 year program are much better qualified in radiological health, but lack breadth in the area of important cognate courses, such as industrial hygiene and sanitary engineering. We feel that these courses are needed at the professional health physics level. Also, the 1 year student may lack an insight into the problems of research. We actually do not look too favorably upon even the 1 year program.

We'd rather emphasize the 2-year program, where the student can complete, not only all of the radiological health courses, but courses in the other areas closely allied with radiological health. In the 2 year course, students are permitted to do independent research and also gain practical experience in health physics. We strongly advocate that the student stay for the second year, complete the master of public health degree requirements and be trained not only in depth but in breadth as well.

Doctoral students are exceptionally well-qualified in health physics. The teaching experience and work on practical problems enhances somewhat their professional ability.

In conclusion, we feel that the radiological health program at the University of Michigan is a good start on the problem of training in this important area. It is not perfect by any means and will continue to be changed and improved as experience indicates and as requirements for professional health physics training demand.

Professor Joseph J. Fitzgerald: Radiation problems have been recognized in many instances as public health problems. And in recognizing this, I think schools of public health should consider the development of a flexible graduate program in radiological health.

This program would be most effectively designed, from a public health viewpoint, if it presented a perspective of the total exposure to all environmental and industrial hazards.

We must, therefore, take into consideration all types of hazards not only radiation. But we would put a definite emphasis on ionizing radiation.

It seems appropriate here, for the purpose of clarification, to raise the following questions:

What type of educational programs are necessary to prepare personnel for the assumption of responsibilities in radiation protection and control?

What should be the prerequisites for these programs?

What should the curricula contain?

Should a practical training program be developed?

How can these programs be integrated in the best manner into existing educational programs?

Thus, we have five areas of concern: programs, prerequisites, curricula, the training program, and integration of these into existing programs.

I won't discuss integration into existing programs because it is to be discussed in detail later. But I'd like to talk about the other four — program, prerequisites, curricula, and training.

Programs should be designed to meet the need for radiological protection and control, depending upon the professional areas and the functions for which the personnel are being prepared to assume responsibilities. Personnel may be prepared to assume administrative teaching, or research responsibilities. Under such conditions, we might consider it appropriate to have three programs.

A 1-year program might be adequate for administrative and operative personnel -- and I say it might be. This does not mean that these students should not go on to further study. If a person is going to carry on administrative and operational responsibilities of a broad nature, the use of a 2- or 3-year program may not be inappropriate in his case.

For the teaching and the research group, the minimum of a 2-year program is desirable, and preferably a program leading to a Ph.D. In general, functions and areas of responsibility indicate that it might be logical to have three types of programs, the 1-year, 2-year, and the Ph.D.

The content of these programs would be best determined by an analysis of the responsibilities, the authority, and the accountability that is frequently invested in radiation protection and control personnel. In 1959, an analysis was made of these functions in 35 health physics organizations. The results showed:

In personnel monitoring — in-plant and environmental monitoring, records, calibrations, and counting room operations -- these responsibilities were invested in 77 to 97 percent of those persons whose areas came under the survey; and

Bioassay, waste disposal, decontamination, and radiation work-permitting authorization — the ability to authorize or state whether or not a person can go into a restricted area and issue such a permit -- 49 or possibly 50 to 60 percent.

Instrument repair, radiochemical analysis, nuclear safety or criticality, meteorology, radioactive laundry operations, and reactor safeguards -- these groups represented 20 to 43 percent.

In other words, 25 percent have broad areas of responsibility and 50 percent or more cover personnel monitoring, bioassay, decontamination, waste disposal, and so on.

In looking at the responsibilities which a health physicist may be called upon to assume or the responsibilities invested in him, we must recognize that he must be in these areas. Radiation physics, radiation chemistry, radiobiology, industrial hygiene, to some extent, environmental hygiene, toxicology, epidemiology -- all of these areas must be considered in our program if it is going to be effective and complete in all its aspects.

Before entering the program, he should have had 2 years of physics, or 1 year of physics and 1 year of engineering; 2 years of chemistry, or 1 year of chemistry and 1 of biology; in addition to courses in the physical sciences, perhaps for 2 years.

Assuming that a candidate possesses the prerequisites, what are the courses that he should take? In essence, courses should be given in radiation physics, radiation biology, toxicology, epidemiology, radiation chemistry, radiological engineering, environmental hygiene, statistics, industrial hygiene, and seminars.

During the past year at Harvard, we have given a course that follows the 1-year program (see p. 108): Radiological hygiene, or radiation physics, in both the first section and the second half year, human physiology, biostatistics and epidemiology, chemistry of nuclear materials, and special environmental problems. This course covers noise, heat, meteorology, reactor safeguards, and all of the environmental problems.

In the second half year, it covers a continuation of radiological hygiene, radiation biology, and toxicology, biostatistics and epidemiology for three periods, radiological engineering, which takes into consideration the development of equations associated with the dispersion of radioactive materials in the air, the third physics course, special environmental problems is continued; and then, aerosol technology and industrial air analysis.

The ideal health physics course is program A, requiring approximately 30 hours of study.

In program B, incorporating the suggestions and recommendations from Chamberlain's report, in the first section is physics; in the second, biology, toxicology, or epidemiology; the third, chemistry; the fourth, engineering; the fifth, special environmental problems; the sixth, mathematics; and the seventh, industrial hygiene. The eighth area would be special topics.

Program C was given at Harvard this past year. It covers about 39 semester hours. In addition, students were required, if they did not have appropriate credits, to take undergraduate courses in mathematics to include differential equations, so we do not list them here.

It appears to be unanimous that there should be two courses in radiological hygiene or radiation physics. In viewing this determination and discussing it, the consensus was that it would be inappropriate not to have at least two courses in radiological physics or its equivalent.

In general, differential equations is either required for admission or it must be taken during the year. This provides background and experience with first class physics evaluations during the course period.

Courses in statistics, biology, epidemiology, toxicology, and aerosol problems should consume from about 25 percent to 50 percent of the course time.

Applied health physics, radiological engineering, theoretical physics and other courses should constitute 10 to 25 percent of the program.

Seminars and special topics in radiation protection and control are recommended for inclusion.

University curricula should be such that the concepts of radiation protection and control are accentuated. We should spend most of our time bringing out the concepts and principles of radiation protection and control for, otherwise, we are going to graduate technicians.

A 10-week training program is found to be effective in the application of course work and the principles of existing problems in radiation protection and control. Here a student is trained to assume the responsibilities and functions that we talked about earlier. Specifically, it would be desirable to familiarize the students with the following activities and areas: personnel dosimetry, in-plant and laboratory monitoring techniques, environmental monitoring procedures and techniques, reactor, cyclotron, hot lab, area surveys, medical and university area survey, the large national laboratory surveys giving him some knowledge of what is going on in the medical areas and in the universities, and looking at the problems associated with the small users of radioisotopes and X-rays, for example, calibration and recording procedures, waste disposal methods, research activities, emergency plans, decontamination methods, meteorological problems, and counting room and radiochemical analysis.

These are merely points of interest that should be taken into consideration in the training program.

In summary, the following comments may be made with respect to the curriculum for radiological health within schools of public health.

There is a demonstrated increasing need for effective education of radiological health personnel. There is no question about this. Radiological health problems are, in many instances, public health problems. Schools of public health can develop most effectively a flexible program in radiological health in recognition of the need and the character of this problem.

Any radiological health curriculum should be flexible and consider all aspects of environmental health with a definite emphasis on ionizing radiation.

This is our purpose but let us not forget that a true public health program should encompass all of the environment.

In general, three graduate programs may be most effectively designed. Although a 1-year program may be appropriate, and I say may, for those students who will assume administrative and operational responsibilities in radiological health, those who assume teaching and research responsibilities should follow a 2-year and a Ph.D. program.

The curricula in all instances should emphasize the principles, the concepts, and the theories, rather than the practical aspects. The curriculum at the universities should be geared for the concepts and the principles, and a training program should emphasize the practical aspects.

Dr. Niel Wald: I should like to commence with several generalizations about our radiation health program of the Graduate School of Public Health at the University of Pittsburgh (see p. 122).

We consider radiation health, in some measure, as another kind of occupational health problem, with ramifications in the entire field of public health per se. It doesn't differ, except in kind, from a problem that may confront the occupational worker who is exposed to benzine, or perhaps the population faced with the problem of air pollution from industry. It is an overall public health problem, susceptible to control under the same principles of management as other similar problems.

Another generalization is that there are different objectives at the various training levels. We've considered at this session, the needs of nuclear industry and of the government institutions which administer and regulate radiation health. But I think one has to consider also the objectives of the individuals who seek this type of training.

The simplest objective is the acquisition of a general familiarity with radiation, its effects and control. For this purpose, we give some lectures in the University of Pittsburgh's medical school in the course in laboratory medicine, for example, with the aim of familiarizing the future physician with the details of the use of radioisotopes, as a particular radiation safety problem.

A similar purpose is served for all of the students in the Graduate School of Public Health, in a general course at our institution which is known as the "Man-Environment" course. In the course, the problems discussed are diverse; an attempt is made to show that the diversity of the problems does not preclude their management by procedures familiar to the field of public health. One such problem area, used as an example, is the developing nuclear technology field. In this example, consideration is given to the potential hazard of radioactive contamination in the environment and its control, in the process of learning what we might call the general public health approach.

For this purpose also, but on a higher level, there is an introductory health physics course open to all students in the school and in the University, for that matter, who may wish to gain some fundamental understanding of radiation, health physics, radiobiology and radiation protection.

Next, let us consider a more complex objective. The candidate for the master's degree has as a major purpose his development as a radiation health generalist — sufficiently familiar with the theoretical problems and practical techniques involved in dealing with radiation technology to apply this fund of information to the fulfillment of his particular role in the field of public health. Many of our students are committed, either by training or occupational experience or both, to a specific aspect of public health, be it medicine, sanitary engineering, public health administration or, in some cases, fundamental scientific fields such as chemistry or physics. To suit their needs, we attempt to teach enough detailed fundamental information concerning radiological health so that they may apply it in their own special field.

The next objective, to become a radiation health specialist, is generally found at the doctoral level. The aim here is detailed specialization in a fundamental area of scientific investigation and perhaps teaching as well. Major emphasis is placed on the scientific disciplines basic to radiation health, such as health physics and radiobiology, but again with the requirement of obtaining a general knowledge of the applied area in which these particular disciplines fit, and the particular public health aspects attendant on their development.

So much for the objectives of the students. We will now consider how they fit into the planning of a training program in radiation health.

Radiation health, and this is another generalization, is pretty much an applied field of knowledge. It is approached on the basis of the scientific data accumulated in the more basic fields of health physics and radiobiology, primarily. Health physics as used here covers nuclear physics, radiological physics, instrumentation, and application of instruments in practical uses. Radiobiology means, broadly, the knowledge of radiation chemistry interactions at the molecular level through effects on cells, tissues, organs and organisms, to actual human radiation injury, both immediate and long-term.

These two fields are the basic scientific fields from whence comes the fundamental data, the details of which must be focused or directed by an occupational health or public health approach and methodology, in order to be useful when applied to the solution of problems which have to do with radiation health. The fundamental scientific knowledge in the fields of physics, nuclear physics, health physics, biology, or radiobiology could be taught as well in other parts of the university but the organization of this knowledge and its application to radiation health problems is uniquely the type of training which we feel can be carried out in a School of Public Health.

There is perhaps less need for locating in a school of public health the particular type of program which produces a doctoral level specialist who is going to carry out independent research or teaching. Yet we believe that if his overall efforts will be toward supplying scientific data or training workers for the field of radiation health, he, too, would have more understanding of where the basic scientific fields fit into the overall public health picture if he obtains his doctorate in this setting.

Turning now to the details of the teaching program, we have three areas of activity which provide the basis for our training; the didactic teaching or the course work; the collaboration of students in research programs; and finally, the participation of students in field work.

One point I should mention before discussing the curriculum of the didactic course work is that at the University of Pittsburgh, we are operating under a trimester system.

Originally we considered it necessary to use 2 academic years even for the master level. With the advent of the trimester system, giving us an 11-month academic year, we can supply training fundamental to the field of public health in one academic year and meet the requirements for the master of public health degree, or the master of science in hygiene, as well as completing the radiation health training.

In order to get the radiation health approach that we want, even in basic courses such as nuclear physics, it is necessary for us to keep the training under our wing, so to speak. Whenever we have tried to use courses in other parts of the University, we found that we were not satisfied because of the shift in orientation which occurred. For example, this was noted when we used the nuclear physics teaching staff of the engineering school. They were looking at radiation from another standpoint. The same thing happened when we used the hospital physicist, or so-called radiological physicist, in field work in which our students watched patients undergoing radiation therapy. We wanted to show the general effects of radiation on the human, and the hospital physicist was concentrating on the dose to the cancer cells. Even in that instance, he wasn't looking at the subject in the way that we wanted for our students' instruction.

We believe that radiation health is and must be part of a general public health program. The first trimester, therefore, emphasizes those courses basic to public health.

We begin more specialization in the second trimester with the laboratory component of the health physics course as well as the beginning of the radiobiology course. Here we separate the two major differences in background: emphasis for physicians is more on occupational medicine, whereas the engineers deal with the control of industrial hazards.

It is in the second trimester that individual research work for the master of science candidate begins, in addition to the course work which has been going on.

In the third trimester, we are able to have a high proportion of special studies, which means field work as well as the completion of research and work on these.

The students generally are encouraged to take part in on-going problems or a new problem if it interests them and if it is susceptible to adequate handling in a relatively short time. They have about half a year for this purpose, and there is quite a bit of free time toward the end of the school year for it. This research can be in the field of health physics or radiobiology. Radio-epidemiology is another type of study which many of the students find interesting.

The field work is carried on in several institutions. We utilize the University Radiation Safety Service which deals with isotopes in research, and therapy, as well as with linear accelerators and cyclotrons. Also, we have access to a reactor facility, privately owned by Westinghouse, which we are able to use for all of our teaching purposes. There we have a large 60 megawatt test reactor, and four small swimming pool reactors.

Before any of the students are exposed to this part of the field work, they have had some practical experience at the school, up to and including use of our calibration facility, X-ray apparatus and some work with a subcritical reactor which we have installed for training purposes. This makes the actual field work much more meaningful.

The fifth and sixth terms form the period in which we feel that the basic principles learned earlier should be converted into practice. At the radiation health seminars, the principles obtained in health physics and radiobiology course work and laboratory work are integrated and applied to public health problems, calling on the public health course work and training which the students have received throughout the entire program. Examples of such problems are the setting of specific maximum permissible concentrations (MPC), and reactor site selection. Certainly, administrative and legal problems fit into this general heading.

To summarize, we believe that in radiation health, the specializing student must have fundamental work in the fields of health physics and radiobiology, accompanied throughout by the various courses fundamental to the field of public health and more specifically, to the field of occupational health *per se*. A period of consolidation of the didactic material in field work is highly desirable, as well. The nonspecialist's needs are served by more general descriptive courses in this area. Because of the diversity of basic scientific disciplines and applied public health principles contributing to the general field of radiation health, it is appropriate that a training and research program in this area be carried out at a school of public health.

Professor Emil T. Chanlett: For the last several years, we have been trying to bring radiological health into our program of instruction at the School of Public Health of the University of North Carolina (see p. 118). This has been more in the pattern of natural selection rather than planned parenthood, depending upon faculty readiness, discernible need, and student receptiveness.

We have tried to move forward, but I don't know that I can say that we ever sat down and calculated a plan on how to achieve this. Nevertheless, among those faculty members who have brought radiological health instruction into our curricula, two concepts have been identified and embodied into our efforts.

The first is that all public health specialists must be prepared to meet radiological health questions at their working level and in the context of their normal responsibility. Nurses, sanitarians, medical ,health officers, all will sooner or later meet a radiological health question of some type.

The second is that a maximum effort must be made to introduce radiological health phenomena as a part of functional subject areas rather than as a unique and different case in respective programs of study.

Examples are behavior of radionuclear contaminants in water treatment, discussed in a water-waste unit process course; public attitudes toward radiological health hazards, in a health education course; evaluation of strontium-90 in food, in a milk and food sanitation course; industrial radiography hazards, in a course in industrial hygiene. The intent is evident, that radiological health should not be regarded as a specialty beyond the scope and capacity of public health practitioners.

This is in no wise to imply that very highly skilled consultants are not needed, the very sort we've been talking about up to now. Nor is it the intent to exhibit the naivete that problems will not be frequently encountered requiring very specialized knowledge.

But public health practitioners in radiation, in their own daily rounds, must know what it's all about so that they can be used, and recognized by other public health workers as factors which merit interest and are part of the overall responsibility.

The process of integrating radiological health into regular courses requires two things and these are not easy to meet. One, the student must be provided with some grasp of the basic concept of nuclear physics, however elementary, and second, the faculty must be prepared to work radiological health topics into their course areas.

Let me tell you a little about how this has been accomplished at the University of North Carolina, without attempting to claim any vast success for the effort.

Our student body is not different from other schools of public health. We have about 100 to 120 students per year, and they divide about 30 in health education, an equal number in sanitary engineering, about 20 in public health administration, one half of these being physicians, about 4 or 5 dentists, 1 or 2 veterinarians, and some nonmedical administrators. The remaining 40 odd students, all at the graduate level, are divided fairly evenly among microbiological specialists, public health nurses, statisticians, folks interested in maternal and child health and in mental health.

The educational and experience background of these students is even more heterogeneous than the basic composition of the group.

We use two devices to bring to these people some understanding of the elementary concept of radiological health.

The first has been to work it into one of our courses, which we happen to call "principles of sanitation." And as time has gone on, we have succeeded in allotting an increasing amount of time to those areas of physics which are pertinent to environmental health factors.

In order to achieve a tie with the student's existing knowledge and experience, we've been approaching this topic through the electromagnetic energy spectrum. This throws a slight scare into them when they see it announced on the program of instruction, but they soon realize that if they begin with familiar topics, such as visible light, heat, and radio waves, they then can stand the jolt of transition to X-ray, gamma rays, and cosmic rays.

By establishing the character of X- and gamma, we are then able to introduce the nature of nuclear reactions and to discuss other types of emission. Emphasis is placed on the ionizing character of radioactive emissions, relating this to our methods of measurement, systems of units, and character of biological damage. The goal of this instruction is not depth but recognition of the phenomena of ionizing radiation.

Within our present frame of instruction, we are able to devote approximately 7 or 8 contact hours to this matter within the course. Obviously, this is scarcely sufficient to introduce the subject, so we have used a second major device to extend the student's instruction and orientation to radiological health.

For the past 6 years, we have conducted a 2-1/2 day radiological health seminar, held during the last week in January at the interval between the termination of fall semester examinations and the beginning of the spring semester. Attendance is voluntary and there are no examinations and no preparation required. Our dean and department heads have supported this in the main and as the students have recently returned from the Christmas vacation on which they have spent all of their travel money, all of their spare money, and all their beer money, they come to the seminars.

Fortunately, we have been successful in having outstanding speakers, people who enhance the attractiveness of the sessions. Every effort is made to limit the amount of didactic lecture and to present the material through discussion sessions, equipment demonstrations, and the use of visual aids. Optional sessions are set up so that the student may find things which are related particularly to his specialty interest.

This radiological health seminar was initially conducted by the Department of Sanitary Engineering, with the support of the U. S. Public Health Service, and was evolved through joint planning by the Departments of Sanitary Engineering and Public Health of the school. The North Carolina State Board of Health has joined us in this. In addition, we have had participants from the Oak Ridge National Laboratories, the Oak Ridge Institute of Nuclear Studies, and we have had the continued support of the Public Health Service and the department of radiology of our School of Medicine. May I acknowledge Roy J. Morton's fine support in this effort.

This period of exposure and orientation gives a common base for further development of radiation topics in other courses. We have had a gradual and an encouraging utilization of these opportunities. For example, in a course on statistical methods, we have a problem involving strontium-90 in milk. In epidemiology, radiological exposure data is used in a problem. In parasitological research, where radiation is used to modify the characteristics of microorganisms, the nature of biological reactions is discussed. In public health administration, a problem on the organization and function of the nuclear incident control team is used. In occupational health, the examples are many, and we've used them for many, many years.

Our health education staff has an interest in developing a suitable situation for their use. We anticipate an increased number of opportunities to do this type of thing.

Up to this time, there has been no plan of concerted effort to raise the level of faculty readiness in the area of radiological health. I speak here of the faculty in toto of the school. This has rested on individual initiative. About 3 years ago, we did bring together the faculty in a 3-hour session to discuss the significance of radiological health to their particular functions and interests. Perhaps as a benefit from this, there has been an increasing involvement of many faculty members in the planning of and participation in our radiological health seminar.

At one time, we had a marked hesitancy on the part of the faculty to commit itself to even so much as designation as a moderator in a seminar session. But this has gradually eroded, and we have had a very good faculty attendance at these seminars each January.

Two of us have enjoyed the very real privilege of being research participants at the Oak Ridge National Laboratory on assignment to the Waste Engineering Laboratory. One of our faculty members participated in the course mentioned yesterday on orientation in radiological health for health educators at the Sanitary Engineering Center. I hope he shall prove a convert. Several of the faculty members attended short affairs — 2-day and 3-day orientation — such as offered by the Office of Civil and Defense Mobilization.

One valuable resource available to our faculty has been the presence of two senior research staff members from the Venereal Disease Laboratory of the U. S. Public Health Service which operates in conjunction with our school. These men are well-prepared and use radioisotopes regularly. They participate in all of our teaching efforts. These people have supplied the guidance and developed material for inclusion in courses, although we have preferred to have the usual instructor present the material.

Although all of these efforts may seem quite small in view of the vast ignorance and misunderstanding that exists concerning radiological health phenomena, there is full confidence that in the long run, this procedure will be rewarding.

Our teaching efforts within the school, however, have not been limited to this matter. We introduced a course some 5 years ago, entitled "Radioactivity in Water, Food, and Air." This title was calculated to raise the least trepidation on the part of our graduate school committees, which review new courses. It seemed legitimate for a department of sanitary engineering to embark on such a venture.

We had a generous gift from the Division of Biology of the Atomic Energy Commission, which provided the basic equipment for laboratory instruction. The Robert A. Taft Sanitary Engineering Center, through their training branch in radiological health, has given us a good deal of help with teaching materials and laboratory exercises.

After about 4 or 5 years, we finally reached the point in this last school year where every student in our department (Sanitary Engineering) completed this course, as part of his degree requirement.

This necessitates offering the course both in the fall and the spring. Up until this time, only half of the students who wished to elect the course in the spring offering were able to participate, essentially because of laboratory and time limitations.

With such an introductory preparation for our sanitarians, our sanitary engineers, our sanitary chemists, biology specialists, and our air hygiene majors, it has been possible to accelerate instruction within their specialty courses on radiological health topics. This has been particularly true in our courses in industrial hygiene, occupational health, and in unit process of water and waste treatment.

Possessing some basic knowledge and understanding of techniques, radiation measurements around X-ray installations, the calibration of field instruments, the use of radioisotopes to study flow patterns in treatment processes, and the discussion of the behavior of radionuclides in liquid and airborne wastes, have been included in a regular course of instruction pertinent to the specialty courses which these men take.

We look to the early development of additional course instruction for our students within the department of sanitary engineering, for greater depth in areas of radiological hygiene.

Essentially it is a matter of time and the readiness of both our faculty and students which determines the rate at which we may accelerate our further development of radiological health instruction. Here again I speak not in terms of the preparation of the specialist, as has been discussed by the four speakers this morning, but rather the broadening of the capabilities of the several public health practitioners. All of us on the staffs of schools of public health, or recent students, know that we are undertaking a herculean task within a single academic year. Many are already seeking to add 3 months beforehand, or 3 months after, to bring the total up to something in the neighborhood of 11 months of instruction.

Certainly all of us recognize that any substantial extension of radiological health teaching for the broad group of public health students will require that some major part of our traditional material be deleted from our curriculum, or radically diminished. All of us are familiar with the constant and intense pressure to effect such changes. We are amazed that teachers of specialty areas other than our own do not gracefully yield course time to new needs.

Within courses which are of our own immediate design and control, such as the basic course on sanitation, we are giving additional allotted time to radiological matters.

I spoke of this device at a radiological health seminar. It has been successful, but nevertheless it has been a stopgap-type. But I throw it out to you as an example of a device by which you can get the camel's nose in the tent.

If we are to supply a minimum contact time of about 20 hours on radiological health orientation, we must create a new course or certainly increase substantially the total length of our course in sanitation. Any suggestion of this sort, of course, brings angry cries from the curriculum committee or similar faculty body.

We have noted that schools of public health are already extending their time for the master's level beyond 1 academic year. If this relief is granted, those of us carrying a radiological health banner will need to run at a sprinter's pace to get a seat in a front row, because virtually every other specialized health area will be competing to get the extra time.

I do think that we will have the benefit of prior knowledge as time goes on. Entering students will have some experience and some familiarity with nuclear phenomena in their sum total of learning and knowledge. This material is becoming part of formal instruction at the high school and college level, and when students finally arrive at our doors, we will be able to scale our instruction accordingly.

On the other side of the coin, I suppose one might say that by that time, our knowledge in this field will be amplified in volume and detail with additional time needed to encompass it.

One or two closing statements are appropriate. We must continue to prepare all of our public health practitioners with some reasonable comprehension or some degree of skill to deal with the questions of radiological health as they encounter them in the field. If I have any theme, then this perhaps is the theme. This cannot remain the private domain of the radiological health specialist. He must share it with the public health nurse, the sanitarian, the health educator, and the administrator.

We may have in these students with a motivation to learn, our most important product of schooltime learning, a comprehension of the nature of radiation and its effect on the health of man. These people may feel that they then have some privilege and some knowledge with which to enter into the sacred confines of radiological phenomena, nuclear physics, health physics, medical physics, or whatever title we may wish to use.

Dr. Gaylord Anderson: We have to think of public health as the synthesis of the contributions of a great many different disciplines, all of which have something to contribute to the solution of community health problems. It's the synthesis of the contribution of the physician, the engineer, the chemist, the physicist, the veterinarian, the nurse, the educator, the statistician, and so on.

Each discipline contributes something to the overall program, and we try to put these contributions into some sort of balance. As new problems arise, and they have arisen recently in radiological health, we get more contributions to be welded into an entire program. It is the responsibility of the health officer who is the administrator of the program to bring all of these contributions into some sort of balance.

On the other hand, there is not a single member of the public health team, no matter who he or she may be, who can live in such a hallowed environment, unaware of or unaffected by the problems of the other fields of endeavor.

Dr. Chanlett referred to the public health nurse. Granted that the public health nurse is not going to be playing a great part in the control of radiological hazards. On the other hand, there's no member of a public health team who has a closer association with the public.

The general public is influenced by what is told them through the newspapers or otherwise, and brings questions and worries to the public health nurse. If she represents the health department and she says that she hasn't heard of the subject and knows nothing about it, or she says she read about it in the newspaper but doesn't know what they're talking about, she has missed a gorgeous opportunity to bring the services of the health department to the public. She's missed the opportunity of creating an informed public opinion.

We've got to remember, whether we like it or not, that the public is being exposed to a tremendous amount of exaggeration and misinformation with respect to radiation hazards. It was brought out to me rather forcefully recently.

I was speaking at a meeting on the University campus that had absolutely nothing to do with radiological health. As the meeting broke up, two of the faculty wives cornered me separately and expressed some concern because there had appeared recently in the newspapers statements made by persons of a scientific background regarding radiological hazards within the State of Minnesota — such as strontium-90 in our milk and in the dust that was floating over Minnesota. One woman said she and her husband were seriously considering leaving the University of Minnesota to escape from this hazard. They were going to sell their home and he would give up his position and find a position elsewhere, not because they weren't satisfied in Minnesota but because of the hazards.

In the other case, the information came from a newspaper story. The couple had a daughter living in New York City who had some particular ailment. The physician in attendance told the daughter that under no circumstance must she ever venture back into the State of Minnesota if she had any hope of living.

This is the sort of stuff presented to the public and this is the sort of stuff confronting people in health departments. The public health nurse and the much maligned health educator have been facing this situation.

It becomes imperative, therefore, in our program for training the public health nurse, the health officer, and the health educator, that we include radiological health. We're cheating them if we don't do it. And not only are we shortchanging them, but we're shortchanging the public.

Those of us who are doing undergraduate public health teaching have the responsibility to try to give the public some understanding of radiological hazards. We give lectures on radiological health in freshman hygiene, or whatever it may be called, to help create informed public opinion.

Dr. Chanlett has raised the question, "How are we going to get this subject in?" Are we going to put this in as a special new course, so labeled, on radiological health or are we going to integrate it as part of a general course on environmental sanitation, environmental health, or whatever term you want to use?

Personally, I have a very strong feeling of agreement with Dr. Chanlett that we've got to make it an integral part of a general course. We must make certain that every student that goes through a school of public health is introduced to radiological health as a part of his instruction in environmental health.

I agree that the amount of instruction is going to vary. The instruction given to the public health nurse, the dentist, the health educator, and the veterinarian may be quite different. The engineer who is interested in general public health engineering and does not want to be concerned with food sanitation or water or waste sanitation may be given more instruction than the public health nurse. But obviously their instruction is going to be less than that given to those who are going to work with radiological hazards.

While we can establish special courses for those who are going to be working in the radiological health field, I feel it would be tragic if, for the others, we were to set aside a separate course and say, "This is a course in radiological hazards, or radiological health," as though it had no bearing or relationship to the whole program of environmental sanitation.

To be sure, we have the problem of getting this subject into an overcrowded curriculum. Every time we have a meeting on a particular topic, we run the risk that some will want to take over the whole curriculum.

We may have to lengthen our program. Practically everybody in the Minnesota program is today on a longer program. Our program is 11 months for the engineers, health educators, sanitarians; our nurses are on a 12- to 15-month program. Our physicians are the only ones left on a 9-month program.

Or we may have to condense other things. In our general course on sanitation, we may have to cut down some of what we used to give on water and sewage disposal, perhaps thus finding the time to add some of the newer things like radiological health and air pollution.

I don't defend the scant time allotted to many of these areas of interest. They are important, but if we cannot lengthen our program, we must eliminate something; we must weigh the relative values in terms, not of the problems of 5 years ago but the problems of today and the problems of tomorrow.

We must integrate radiological health into an existing program. I feel very strongly that this is the sound way to accomplish our purpose.

The next question is, "How much are we going to add?" I don't pretend to know that. I don't suppose that we'll ever reach agreement. No one so far has made any reference to the two reports of the World Health Organization, Reports No. 154 and No. 155. Report No. 154 is entitled "Postgraduate Training in the Public Health Aspects of Nuclear Energy", and No. 135, "The Introduction of Radiation Medicine into Undergraduate Medical Curriculum."

Report No. 154 is the report of a committee which met in September 1957. I was a member of this committee under the chairmanship of the late Sir Ernest Rock Carling. We met for a week with representatives of different nations.

Apparently, my function on the committee was to see that they didn't run away with the entire public health curriculum. Actually the committee was very reasonable in its demands, and this report contains some very good recommendations.

We attempted to divide the courses into four groups. There is an orientation course of 8 or 9 hours, which might be a basic universal course for most public health personnel, medical and dental personnel, public health and industrial nurses, health educators, hospital administrators, sanitarians, and the like. The committee defined its ideas as to the relative amount of attention which should be given to various topics.

The second level is called an "introductory course," which is a suitable and basic curriculum for industrial medical officers, sanitary engineers, and statisticians, and serves also as a second course for medical and veterinary officers not expected to have special responsibility in atomic energy matters. The time is estimated at about 60 hours.

Two other courses are listed, an advanced course similar to our discussion earlier today and a specialist course, which would take "X" years, an unknown. Saying that it would require less than a full academic year has been carefully avoided but it was the belief that 1 year would be a very low minimum. Some suggested that even a longer time would be needed.

Even though I signed the document, I'm perfectly willing to admit that we haven't accomplished all of this in Minnesota (see p.116). It does, however, give the schools of public health a guide to the thinking of a group of persons from a number of different nations who were concerned with this problem of teaching the public health aspects of radiological health.

We are not doing as much in Minnesota as we would like to do, but we are doing something. There is not a general course in the school that does not have its component of radiological health. We haven't as many hours in this subject as we would like. In our instruction, we've had to rely on our cooperative relationships with the other parts of the university. We have 3 full-time persons in the university who are charged with controlling radiological hazards on a campus which has some 70 X-ray machines on it, a couple of cobalt units, an accelerator, and so forth. We have so many hazards that it takes three full-time persons to control them. I cannot take time to tell you of some of the hair-raising problems that they run into at one time or another, but it has made excellent teaching experience for our students.

This morning, reference was made to the importance of the medical aspect. Our three control men operate within the hospital building and every day they're monitoring hazards like the X-rays, the use of isotopes. Without having to go out of the building, we can show our students this work and show it to them as an integral part of a program of environmental control of the whole University campus.

We are not doing as much as we would like, not as much as we hope to do, not as much as we intend to do in the years that are ahead. If we have done anything, I think that we have accomplished most by saying to the students that, regardless of whether they be a health officer, nurse, or engineer, one of the responsibilities they will carry in one form or another and in varying degrees is the problem of radiation. Our students get instruction on radiation in sanitation, in epidemiology, in health education.

How do we integrate instruction in radiation into public health? I was a bit disturbed this morning by one or two of the programs presented with the feeling that there wasn't enough public health in them. I had this feeling about the Harvard program. Of course, being a Harvard graduate, I feel a special privilege to criticize Harvard. As I saw the Pittsburgh program, I was a bit relieved. I saw more public health.

I think that we must be very cautious, as we train our radiological health personnel, to avoid the temptation of putting so much radiological health in the curriculum that we lose sight of the fact that these students are going to be operating as part of a community health program and they've got to know something about health, not just radiation.

In the Pittsburgh program, there was a reference to public health administration. I missed it in the Harvard program. How can a person relate to a complete health department program if he has no understanding of the concept of public health administration and public health practice? It may have been in the Harvard program and I may have missed it.

I fear that in some cases we may be making the same mistake that we've made in other fields of public health -- getting so concerned with our own special aspect of it that we've lost sight of our relationships.

I hope, as we develop these programs, whether they be 1 year, 2 years, 3 years, or "x" number of years, that we don't lose sight of the importance of retaining and emphasizing some understanding of overall public health programs, as a springboard from which to start.

Schools of Engineering

P. H. McGauhey, Professor of Hydraulic and Sanitary Engineering, University of California, Chairman.

Professor John E. Kiker: The effect of radiation upon people is primarily a medical problem. The safe design and operation of nuclear reactors are an engineering problem. The disposal of radioactive waste materials from medical institutions, industrial operations, and research organizations is the responsibility of sanitary engineers who must be competent in areas of environmental health and familiar with the production and control of radiation hazards.

It's apparent that close cooperation by persons with diverse training and experience is essential. The problem of control is essentially based upon teamwork by groups composed of physicians, physicists, and engineers including sanitary engineers. The importance of one should not be emphasized over the importance of the others in contributing to the basic responsibility and service of the team as a whole. However, it is the sanitary engineer who is most intimately concerned with the broad public health aspects of the problem. The effects of radiation on human beings and other biological organisms is the direct concern of the physician. Workers exposed to radiation in industry and in research units can be trained to observe safety precautions and can be supervised best by the expert radiation physicist. But the mass population of any community must be protected from the hazards of radiation by full control of all environmental factors -- air, water, food, and others — and this is the area in which the sanitary engineer has the basic and most effective training and experience.

In many instances, the sanitary engineer must assume leadership in programs of control of these new and rapidly expanding public health problems. The hazards of radiation and radioactivity merely contribute an additional element in the scope of sanitary or environmental engineering.

Yet the complexity of radioactivity and nuclear science require skills which were not included usually in definitions of sanitary engineering until 1954 when the current definition was adopted by the Committee on Sanitary Engineering and Environment of the National Academy of Sciences — National Research Council. Additional and highly specialized training is required for sanitary engineers who are to be concerned with control of radiation pollution of water, air, food, and other components of the environment. This in no way disregards the need for all sanitary engineers to become familiar with the basic principles of nuclear science and the accepted procedures for control of radiation hazards.

The problem of curricula thus embraces general basic training for all sanitary engineers and specialized training for the specialist who will be concerned principally with problems of radiological health, and the administration and direction of programs and of groups of workers in this field.

The development of a rational curriculum in this relatively new area is not simple. Present curricula in all areas of engineering and particularly in sanitary engineering are already overcrowded. To insert new and highly specialized courses within such crowded programs is difficult because all of the existing courses in the basic phases of engineering and science are also needed. To merely add new courses will overload the student's program beyond reason. Thus in some instances revision of the scope of existing courses is essential. This is particularly ture in the undergraduate curriculum where the initial training in radiation problems should begin. For the undergraduate curriculum, the basic science courses in general and mathematics in particular require greater emphasis and possibly some revision as a foundation for the essential beginning training in nuclear science.

An introductory course in modern physics should incorporate the basic principles of nuclear energy and the production of radioactive substances. Similarly, courses in chemistry should include some radiation chemistry. The content of certain specialized sanitary engineering courses, such as industrial waste treatment, can easily be reorganized to provide consideration of radioactive wastes as an industrial problem. A course in the application of laboratory examinations to problems in sanitary engineering should be a part of any well planned curriculum. Here the techniques for detection of radiation and the always important question of adequate sampling can be included readily and without undue disturbance of the scope of the course.

Such a program will introduce a student to the problems of radioactivity and radiation hazards. He will then be able to decide if he wishes to pursue this particular phase of sanitary engineering further. If he does not have such an interest, he will have acquired enough knowledge to approach problems of radiation with an intelligent appreciation of what they are all about.

In the graduate programs, more intensified training in radiation science must begin. Every sanitary engineer seeking a master's degree should be oriented in this field and be taught to participate effectively in sanitary engineering programs involving the control of radiation hazards. However, the graduate degree should be based upon a major in sanitary engineering, which means that all of the usual phases of this professional program should be continued and the specialized basic education in nuclear science added.

Among the topics which should be included early in this specialized program are the following:

1. The principles of radiation and its production by nuclear fission,
2. The biological, chemical, and physical effects of radiation, particularly on the population, and the limiting allowable concentrations of radioactive materials in the various phases of the environment,
3. Methods for the detection and measurement of radioactivity in the environment, including a knowledge of the required measuring instruments and their manipulation,
4. The hazards of radiation, techniques for protection of the environment, and prevention of pollution from radioactive substances, and
5. Procedures for the elimination or reduction of radioactive contamination in air, water, food, wastes, and other environmental factors.

Much of this needed basic instruction can be given in advanced courses of nuclear physics and radiation chemistry. A course, even if brief, in the medical aspects of radioactivity and radiation should occupy an important place in the graduate curriculum.

A specialized course in the problems of radiation in sanitary engineering and environmental sanitation is basic and should be required of every student studying for a graduate degree in sanitary engineering. The content of such a course must include consideration of the treatment and disposal of radioactive wastes, the effect of such substances on stream uses, and the procedures for the treatment of water and sewage. Of fundamental importance are techniques for radioactive monitoring of water, air, and allied substances, and the interpretation of such monitoring data as a basis for programs of control of hazardous conditions. The uses of radioactive isotopes in sanitary engineering, particularly as tracers of pollution in streams, in delineating flow patterns, and in determining the effects of different processes of sewage treatment, are an essential part of such a course.

The course should consider not only the potential uses of radioactive isotopes but, of greater importance, how they can be used effectively and without the production of additional hazards, either to the user or to the environment in which they are used. A course as described should be so developed as to provide not less than 3, or better than 6 semester hours of credit. It should include lectures and adequate laboratory exercises on sampling, detection, and measuring techniques, and instruction in the use and care of instruments.

A full program for the graduate student would thus be provided, since instruction at the graduate level of other phases of sanitary engineering cannot be neglected. An individual qualifying for a graduate degree, usually a master's degree, will be prepared to assume an active role in programs of radiation control and protection.

This assumes that a student, before he comes into a master's program, would have had basic sanitary engineering subjects such as water supply and sewerage. If a student entered this program from some field other than civil engineering, particularly from chemical engineering or mechanical engineering, he would have to make up water supply and sewerage courses without credit.

It is apparent that further specialized graduate training in radiation hygiene and hazard control is essential for those individuals who are to be responsible for planning and administering programs for the control of these hazards. Such further instruction should be at the doctoral level and should be built upon the program discussed for the master's degree. The program at this educational level should include a more comprehensive course in the biological aspects of radiation and should be somewhat similar in content to the basic courses given to medical students.

A knowledge of these biological problems is indispensable to the sanitary engineer actively concerned with control and protection procedures. However, a major part of the program should include actual work in the field of radioactivity as embodied in the kind of research which is an integral part of the qualifications for the doctor's degree with a sanitary engineering major.

The research should be in the area of radiation and radioactivity but should also be related to the basic factors of sanitary engineering. In spite of the vast amount of knowledge that has been accumulated in past years, there is still much to be learned. Thus the field for doctoral research is almost unlimited and many topics can be selected for which original investigation is required to expand existing data or to develop new data.

The sanitary engineer qualified for the doctoral degree should then be as well trained as can be provided reasonably by a university and he should be capable of acquiring by actual experience the further education he will need in this new and complex specialty.

In summary and conclusion, the control of radiation hazards for the protection of health requires a competent team of specialists, on which the sanitary engineer is an indispensable member. The sanitary engineer generally should be the leader or the administrator of essential programs for the protection of the public health through the control of environmental pollution from radioactivity.

The course work required for the education of the sanitary engineer specializing in radiation problems must be expanded to include not only the accepted phases of engineering and sanitation but detailed specialized training in the field of radioactivity and nuclear science. Courses in this specialized area should originate in the undergraduate curriculum and be expanded and intensified at the graduate level. In particular, the program at the doctoral level should include problems in radiological research as applied to sanitary engineering and environmental control of radiation hazards. This requires something of a new approach to program planning to include a new and expanding area of sanitation, to supply engineers who are not only oriented generally in this field but who are equipped also with the essential specialized training which will permit them to assume positions of leadership that will be required in the future and at present.

In the past, sanitary engineers have generally been required to take more chemistry than any but the chemical engineer, more biology or bacteriology than in any other branch of engineering, and as much mathematics as the structural engineer. In addition to this rather full measure of the basic sciences, the sanitary engineer specializing in radiation hygiene and hazard control will now have to add physics beyond that normally required of most other engineers except perhaps those specializing in nuclear engineering.

This does not mean to imply that in chemistry the sanitary engineer is as competent as the chemist or chemical engineer, or in biology and bacteriology as the biologist and bacteriologist, or in mathematics as the graduate-level mathematics major, nor in physics will he become as proficient as the physicist at the graduate level.

In the past, the sanitary engineer has always had to lean heavily on the chemist, the biologist, and the bacteriologist, and it is true that most of the basic research in sanitary engineering has been done by these professional groups. In the future, the sanitary engineer may have to lean also on the physicist, particularly the radiation physicist, for much of the basic work and guidance needed in the field of radiation hygiene and hazard control.

Just as the chemist and bacteriologist have done most of the fundamental work leading to water quality standards, for example, so should the physicist be expected to contribute the fundamental work leading to radiological standards. The physician will remain responsible for the overall health program, of course, but generally, he will retain the sanitary engineer as his chief staff officer charged with the responsibility of abatement of pollution or contamination.

It is no more necessary to make a physicist or a "health physicist" out of a sanitary engineer before he can become effective in administering a radiological health program, than it is to make a chemist or bacteriologist out of him before he can administer a stream pollution or air pollution abatement program.

The core courses normally required at the University of Florida for a graduate major in radiation hygiene and hazard control are given on page 107.

Professor Edward J. Kilcawley: From an educational point of view, the mounting problem of radiological health, like other urgent problems in environmental health, has created a perplexing situation in schools of engineering. Education for a special service in an engineering aspect within each area which is important to effective health control involves many engineering disciplines. As a consequence the creation of interdepartmental curricula on a nonprecedented scale is essential. Departmental lines and single departmental requirements can no longer be respected.

Radiological health, though a broad field of practice, is but one of the modern problems of environmental control. Public concern with the growing problems of air pollution, adequate and safe water supplies, the economic treatment and adequate disposal of industrial wastes, stream pollution, adequate housing, proper land use, accident prevention, and the control of incessant noise and vibration emphasizes the immediate need for a new and integrated approach to the problem of control of the whole of the environment.

Dr. LeRoy E. Burney, Surgeon General of the U.S. Public Health Service, has stated that it is not overdramatic to suggest that the threats from our environment, both actual and potential, can generate not only wholly undesirable effects on the health and well being of isolated individuals but, under certain circumstances, could affect large segments of our population and threaten the very existence of our Nation.

An educational practice since engineers were first called upon in connection with safe water supplies, sewage, treatment of wastes, and drainage to control malaria, has been to designate this field of practice as sanitary engineering. Like other branches of engineering education, education in this area developed as a part of civil engineering which itself was established by separation from the military. Unlike other branches of practice, instruction in sanitary engineering has, with a few exceptions, remained a part of civil engineering.

This situation has continued in spite of the fact that effective practice in the traditional areas and an understanding of the newer areas of environmental control are more and more dependent upon science not essential in the segments of practice covered in civil engineering. Options offered as a part of civil engineering curricula are for the most part inadequate. Students are not attracted to them. As a consequence, enrollment is far below that needed for a practical case. Furthermore, in satisfying the curricula requirements for the degree of bachelor of civil engineering, there is insufficient time for the science courses essential to this field.

Attempts to alleviate this situation are made by claiming that sanitary engineering, or the appropriate degree, should be a graduate degree. While it is true that enrollment for graduate study is increasing, it is also true that the majority of candidates are not prepared for graduate level work. The basic sciences must be made up at the cost of valuable graduate time. As a result, graduate work, at least for the first degree, is not on an educational level comparable to that of other branches of practice. The alternative of increasing the time requirement merely creates another obstacle to recruitment of students.

Surveys completed by the U. S. Public Health Service show that approximately 1,000 qualified engineers will be needed annually during the current decade. Current enrollments are far below this figure. Of equal importance is the fact, shown by these studies, that 85 percent of those now serving in this area of practice would benefit by an additional year of study. This is true in the area of radiological health as well as in other areas of environmental control. It is true that much has been done to provide educational opportunities. However, the current effort is inadequate.

The present day situation has developed largely, or at least in part, to a lack of effective leadership on the national scale and to acquiescence on the part of the profession and the schools of engineering to maintaining the status quo. It's both strange and very difficult to understand why, in this time of scientific and technological advancement, the complex, challenging, and ever-changing problems of environmental health have not been sufficiently promoted to compete with other areas of scientific and engineering practice. These problems deal with matters basic to life itself and to the utilization and conservation of natural resources upon which our economy and national security depends.

A new, broader, yet more intensive educational policy is urgently needed. This may be divided into three important parts:

1. The informing of the public, our legislators, and other responsible officials about the magnitude and urgency of the problem, emphasizing the need for enabling and clarifying legislation especially where political jurisdictions are involved.
2. The establishment of university centers having comprehensive programs and competent staffs for teaching, research, and service.
3. The creation of a vigorous program for recruiting students.

It has long been the belief of this speaker that adequate educational experience for engineering service in all areas of environmental health should include both undergraduate and graduate level work. Accordingly, in 1954, he proposed a new 4 year undergraduate curriculum leading to the degree of bachelor of science in environmental engineering (see p. 123). This proposal was critically studied by a campus-wide committee representing the various scientific and engineering fields involved. After certain adjustments, the curriculum was submitted to and approved by the faculty, the Board of Trustees, and the State Department of Education.

Requirements for the degree of master of science in environmental engineering were established in due course. These curricula were first offered in the fall of 1958. Further study is now being carried on relative to work and research requirements for the doctorate.

The undergraduate curriculum differs from other conventional programs in that more emphasis is placed upon the basic sciences and a wide range of electives is offered. This gives opportunity for a relatively high degree of training in one of the several specialized areas such as radiological health, air pollution control, water conservation or design at undergraduate levels. Of much greater importance, it prepares the student to pursue graduate work more effectively. In addition to two terms of general chemistry, the curriculum requires elementary organic and elementary physical chemistry, and quantitative analysis, plus the requirements in general biology, bacteriology, and fresh water biology, and the conventional four terms of modern physics, and a one term course in the introduction to applied nuclear physics. The mathematical requirements include three terms of calculus and a one term course in mathematical statistics.

In the engineering sciences, there is engineering drawing, hydraulics or fluid mechanics, statics and strengths of materials, and electrical engineering. The curriculum provides for eight sequential courses in the humanities and social sciences, one in each term. The following professional courses are required: water resources, treatment, and supply; community sanitation; waste water treatment and disposal; limnology and stream sanitation; industrial waste treatment; environmental design; air pollution; and two terms of environmental engineering laboratory.

Provision is made for one nontechnical elective, and for four technical electives. A fifth technical elective may be substituted for a thesis. These technical electives are: radiation biology, radiochemistry, introduction to genetics, instrumental analysis, ground water geology, physical geology, dynamics, differential equations, site engineering, structural analysis, general structural engineering, structural design, and two courses in reinforced concrete.

We have all three of the ROTC units and in general, 6 academic credits may be given for ROTC work. One-half of these are nontechnical and one-half technical. In the last 2 years, ROTC must be carried as an overload.

At the graduate level, required courses are variable. For graduates who have completed the undergraduate curriculum, the opportunity is available for a deeper study in one or more areas of modern practice. Two flexible courses, entitled special topics in environmental engineering, make possible the development of any specific area for which there is a need. These topics may be a theory, laboratory investigation, or design.

Those candidates holding the conventional bachelor's degree must make up basic science requirements. Insofar as possible, programs are arranged to include graduate level work. As early as possible in his undergraduate study course, each promising candidate is encouraged to complete at least the master's requirements. It has been our experience that this decision can be reached during the first or second term of the junior year. As a consequence, suitable course substitutions may be made during the remaining two or three semesters. This makes possible the postponing of certain complicated scientific and technological aspects of professional courses to graduate study.

I am not, however, agreeing that environmental engineering training is exclusively a graduate program. Certain courses at undergraduate level are essential in order that graduate work may be carried on at an educational level comparable to that of the fields of engineering practice.

It qualifies the candidate to pursue advanced work on an educational level comparable to that of other areas of engineering practice. There is close cooperation between the schools of science and of engineering in planning study programs. An environmental engineering seminar is required in the spring term and term papers and discussions become a part of essentially every course. The preparation of a thesis is optional, provided suitable and approved courses are substituted for them.

In both curriculum planning and study programming, this is a cooperative interdisciplinary program. State students interested in radiological health would be encouraged to take, in addition to the required chemistry, physics, and biology, the following courses: radiation biology, radiochemistry, instrumental analysis, differential equations, introduction to genetics, advanced microbiology, and air pollution control.

A course in radiological health covering such topics as monitoring, disasters, biological hazards to the individual, and reactor control is offered as a part of the special topics in environmental engineering. For the bachelor's degree, four or possibly five of the above courses could be completed. Suitable selections and other substitutions may be made in the master's program.

May I now refer to the urgent need for integrated action and approach to positive environmental health. The engineering schools do not at present have either the students, the qualified staff, or adequate teaching and research facilities to meet even conservative demands for training of engineering personnel. Of equal or even greater importance is the staff and facilities needed to train research personnel and to assist in conducting an expanded and integrated engineering research program in various aspects of environmental control.

It is a matter of record that the schools cannot by unilateral action attract students to this field. As a result it has been impossible for these schools to build up facilities or to hold qualified staff. Furthermore, the maintenance of staff and facilities for graduate instruction is expensive. Attempts to alleviate this are made by carrying on part-time individually supported research projects. This usually results in ineffective performance in both areas because of limited facilities or assistance.

The engineering schools can provide the educational opportunity for training in the health protection and control aspects of radiological health and other areas of overall environmental control. They can also aid in the training of research personnel and at the same time contribute materially to the vast volume of basic research which is so urgently needed. To accomplish this, the engineering schools must have considerable direct assistance, and a coordinated program of student recruitment is essential. Current programs of student aid must be expanded to include undergraduate as well as graduate work. The schools must likewise have substantial financial support for both teaching and research staff and for facilities. Reasonable assurance of continuity of programs must also be provided. This could be accomplished by the establishment of university centers for teaching research and service, provided national leadership is established. It will be very costly; however, the alternative is unthinkable.

It has been pointed out, again by Dr. LeRoy E. Burney, that to develop the environmental health field rapidly, it is essential to go forward with the establishment of broadly based university centers. Such centers can develop comprehensive programs of research, teaching, and service, providing an environment that permits the schools of a university to be grouped together with concomitant influence on the content of course work. Such an environment can obtain the bright, young, free doctorate students and develop them as interested participants in the various fields.

In closing, may I point out that a distinguished contemporary historian has suggested that in the broad sweep, the twentieth century will be chiefly remembered in future centuries not as an age of political conflicts and technological inventions but as an age in which human society dared to think of the welfare of the whole human race as a practical objective. We are now in the sixth decade of that century. If we are to take effective steps toward this objective, the time for action is now! It is not a question of affording it, the point is we cannot afford not to do it!

Dr. Warren J. Kaufman: The progressive reduction in specialization now occurring in undergraduate engineering schools, with greater emphasis being placed on the fundamental sciences, prescribes that the role of the graduate professional school will assume even greater importance in the education of the engineer specialist. The engineer, whether he acquires his specialty competence in an engineering school or in a school of public health, expects the graduate program to enhance his subsequent earning power and to lead to his professional advancement. In achieving this end most directly, specialized graduate education should be closely linked with engineering practice through the creation of professional positions at various levels of responsibility.

Where an appreciable segment of a profession is associated with government service, the education and experience requirements may become quite formalized. The Master of Public Health degree and its relation to membership in the many specialties of the public health profession is an example of this close association of the graduate degree and the opportunity for advancement.

In organizing an engineering oriented curriculum to meet the personnel demands of a new and not clearly established professional area, we must identify current needs and make an objective appraisal of future requirements. Since relatively few engineers are presently engaged in practice in this new area, our predictions of future needs are likely to be optimistically biased. This is the hazard of the situation presented by the question: What should be the nature of curricula in radiological engineering and what will be its relationships to sanitary engineering?

The control of radiation may appear, on cursory examination, to be a specialized activity, but on closer study, it clearly emerges as a multidisciplinary endeavor involving the universe of sciences and applied sciences. Although this universe might well be divided into many spheres, each representing competence in some aspect of radiation control, it is doubtful that any one of the individual specialty spheres could adequately represent the whole and thereby direct the control of all sources of radiation under all circumstances.

Historically, the practice of radiation control developed around two groups of individuals representing, at various times, centers of technical competence. Prior to World War II, the medical profession or, more particularly, the radiologist occupied a nearly exclusive position in the fields of radiation use and control. With the development of nuclear weapons within highly restricted confines of government laboratories, a host of nonmedical radiation hazards appeared, requiring a much deeper knowledge of radiation fundamentals for their control. Since the key scientific discipline in these laboratories was most often physics, it was a natural consequence that certain physicists be assigned to the protection function and that such personnel be designated "health physicists," a term that came into wide, but not universal, usage in the laboratories of the Atomic Energy Commission. It is largely because of this that radiation control and health physics became nearly synonymous terms.

The fields of nuclear science and technology are now well into their third phase of development. Although the functions of the National Laboratories continue with unabated activity, we find that nuclear energy is being employed in a wide variety of ways in nearly every American community. These applications range from the fission of uranium-235 at a nuclear power station to the diagnosis of a thyroid condition with iodine-131 at the community hospital. Each of these situations represents a particular radiation hazard problem that, at least in the public view, may not be dismissed as of little consequence. While the concern for radiation control remained within the precincts of the government laboratory, the cost of what was deemed an adequate control program was of little real concern, particularly when a major portion of the professional operating personnel were also conducting valuable research into methods of control.

At present, however, with industries being urged to develop nuclear energy and to incorporate radioisotope technology into their production schemes, the cost of protection programs and the public relations aspects of such operations are assuming extremely important proportions. Thus radiation control has become an industrial problem and a public one. Whereas the regulation of radioactive materials was once exclusively an AEC function, we now find the U. S. Public Health Service as well as State and local health departments developing control programs and performing limited regulatory functions. It is in this setting that we must make our prognostication of the nature and extent of engineering competence required in the fields of radiation control.

Let us now examine the elements of radiation control in the broadest environmental sense. The primary bases of any hazard control program is the risk that the worker or public considers acceptable and the material loss associated with a given level of acceptable risk. This is not a new or unique concept. On close inspection, one finds our recent bacteriological water quality standards to have origins related to calculated risk and cost of attainment. In the radiological area, the research of the physician and biophysicist in defining the relationships of biological effect to radiation dose and radiation dose to body burden or to the concentration of a radioisotope in air or water allows the selection of permissible concentrations meeting the primary criterion of acceptable risk. After dose rates, total dose, and permissible concentration criteria have been established, the functional aspects of radiation management may be considered to enter the picture. It is at this point that the engineer, together with the applied scientist in chemistry, physics, and biology, would normally become concerned with the problem.

A logical division in the practice of radiation control can be made between the management of sources of radiation and the control of radiation in the environment. Radiation source management encompasses the health and safety aspects of operating reactors, accelerators, X-ray machines, irradiation equipment, and other facilities involving essentially fixed sources where no release of radioactive materials to plant environs would be expected in the normal course of operations. A somewhat analogous role has been assumed by the safety engineer and the industrial hygiene engineer and chemist in the control of chemical and mechanical hazards in industry. Thus radiation source management represents radiation control in the working environment.

Environmental radiation control is more nebulous and difficult to define. It might be considered to have a primary association with the transport processes whereby radionuclides move with water and air from industries and research establishments to man. Thus the total waste fission product problem, from the head-end operations at the uranium reprocessing plant to the establishment of permissible levels of radiocesium in a receiving water hundreds of miles from the plant site, would be representative of the full breadth of the environmental control picture -- from the plant environment to the living environment. Similar examples may be found associated with the liquid and gaseous effluents of nuclear power stations, at hospitals, in research laboratories, and in industries serving the nuclear power complex.

As with most arbitrary divisions of interdependent situations, one may imagine many potential radiation hazards that fall into both of these categories. An example is found in the power excursion of a nuclear reactor that results in the release of fission products. Another example is the failure of a sealed source due to faulty manufacture or improper handling. Although the common hazardous element of both the fixed source and the environmental problem is ionizing radiation, it is apparent that the individual problem solutions may require competence in a host of professional and scientific disciplines ranging from agronomy to zoology and including such diverse matters as soil science, hygrology, meteorology, process engineering, and biostatistics.

Nuclear physics per se clearly plays a relatively minor role in the prediction of the environmental transport characteristics of radionuclides, although we must depend on the physicist for our knowledge of their origin and manufacture. Clearly radiation control is a multidisciplinary venture and by virtue of this characteristic is a field of endeavor open to the engineer.

The engineer may be educated to enter positions of responsibility concerned with radiation control in two general ways. It is certainly feasible to add to the engineer's normal academic equipment some limited exposure to the radiological sciences that relate to his normal specialty area. This would apply to the sanitary engineer, certainly to the nuclear engineer, and probably to the chemical engineer. The other approach is to develop a special curriculum for the express purpose of training radiological engineers. It is believed that both courses of action are indicated, the former on a wide scale, and the latter limited to pilot programs whose growth and longevity will depend on the rate of development of a demand for radiological engineers. However, it is also believed that the demand for engineers in radiation control will certainly be accompanied by an increased need for other radiological personnel with backgrounds in chemistry, physics, and biology.

It is apparent from current trends in engineering education that specialized courses in radiation control are not likely to find a place in the undergraduate curriculum of any branch of engineering. However, with the strengthening of such curricula in the basic sciences, perhaps even including limited course work in physiology and microbiology or in nuclear physics, the engineer receiving a bachelor's degree will be better prepared for graduate education in radiation control and, in fact, in all areas of environmental control. Furthermore, even now various aspects of radiation measurement, radioisotope applications, and radiation effects are beginning to appear in undergraduate engineering courses, including those in civil engineering.

The earliest stage where serious inclusion of radiological courses might appear in engineering curricula is probably in the graduate professional program leading to the master of science degree. However, for some time into the future, inadequate preparation in the physical and biological sciences will undoubtedly dictate that courses in physics, physical chemistry, and biology be completed prior to taking definitive professional courses in radiation control. Considering that the graduate engineering student is concerned primarily with acquiring the "tools" of his professional specialty, it would be desirable to strike a compromise between fundamentals and practice and to provide a flexible program. For example, a nuclear engineering student might select an elementary course in radiobiology, a course in radiochemistry, and perhaps a seminar in the handling of radioactive wastes. Advanced courses in instrumentation and shielding design might also be available. A graduate from such a curriculum would not be designated a radiological engineer, but might well become one, depending on his interest, subsequent job opportunities, and experiences.

A majority of the graduate programs in sanitary engineering leading to the master of science degree are bound by three familiar precepts. The programs must accommodate the typical civil engineering graduate. They must award the Master of Science degree after the satisfactory completion of two semesters or 1 year of graduate study. And finally, they must place a heavy emphasis on water and waste water treatment. Although many contend that these are unwise and unrealistic restrictions, professional conservatism stemming from the strong ties with civil engineering and the practical economics of education subvention will continue to impose their will. Under these circumstances, and assuming the typical program entrant has had no biology and no chemistry beyond the freshman year, it is unlikely that more than a single elective offering in the radiological health sciences would be possible. A course serving this function should preferably cover the entire breadth of radiological science, from nuclear reactions to personnel dosimetry, but should also place special emphasis on those aspects related to water supply and waste disposal.

If significant changes are realized in the liberalization of the undergraduate civil engineering curriculum to include additional chemistry and microbiology, the time now devoted to these subjects in the graduate year may be supplanted with courses in radiochemistry and bioradiology, thus making possible greater emphasis in radiological engineering in the normal Master's program. More important advances in our graduate curricula would result if the great diversity of sanitary engineering problems were recognized and the field subdivided into more reasonable and manageable entities; for example, the water resources, air resources, and public health categories around which the American Sanitary Engineering Intersociety Board (ASEIB) study conference was organized in June 1960. By this approach, the sanitary engineering designation might serve as the standard under which a wide variety of engineering specialists concerned with environmental control might operate. The curriculum would no longer be bound by the "pipes and drains" school, thus freeing air resources, public health, and industrial hygiene engineers to develop programs of courses expressly meeting their needs, which would very probably include more specific attention to the radiological health sciences. Such a liberation would also open the door to a radiological engineering curriculum and serve to place it under the environmental (sanitary) engineering umbrella.

At the present time, those sanitary engineers who receive training in depth in radiation control do so at the doctoral level and this appears under current circumstances to be the only feasible approach. For example, the doctoral candidate at the University of California (see p. 101) is required to complete two minors, each comprising at least 12 semester hours of course work, outside the civil-sanitary engineering fields. A minor in chemistry and chemical engineering might include physical chemistry, nuclear chemistry, colloid chemistry, chemical kinetics, etc. A minor in the radiological sciences could include radiation physiology, biological effects of radiation, nuclear reactor theory, and nuclear physics. The second minor is usually selected so as to have a close relation with the dissertation subject. The dissertations are concerned with some aspect of radiation control, but normally with radioisotope separation from aqueous systems, the movement of radionuclides in the environment, or other areas of interest to the student and bearing a logical relation to his prior experience and training in sanitary engineering.

A similar program may be developed in air pollution control engineering with only minor emphasis placed on the radiological sciences. The graduate from such a program can be designated a radiological engineer but he is (more properly) an engineer scientist with opportunities throughout the breadth of environmental control. He will acquire his specialty designation through experience.

Graduate programs in radiological hygiene especially developed for engineers are currently available in at least two schools in the United States. Without a doubt, several additional will appear in the next few years as Federal funds are channeled into the support of the health associated sciences and professions. Even if the real need for such individuals is initially small, it is conceivable that their capabilities will stimulate a sustained demand and they will become permanent members of the health and safety profession.

A 1-year program in radiological hygiene engineering is offered at Harvard University and was described by Silverman in a paper presented at the American Sanitary Engineering Intersociety Board (ASEIB) meeting on graduate curricula for sanitary engineers in June 1960. Silverman, recognizing the advantages of a background in chemical engineering, considered radiological engineering, together with industrial hygiene and air pollution control, as subfields of air resources engineering and consequently placed emphasis on air analysis, human physiology, and toxicology. Little attention was given to liquid waste control or to the transport of radioactivity in the hydrosphere.

It appears that the major role of the radiological engineer will be analogous to that of the industrial hygiene engineer and quite similar to the area currently designated as "health physics." A majority of the radiation control problems will develop in industries, particularly those associated with power production, and the engineer will be concerned with the design of monitoring systems, methods of limiting and confining minor quantities of aqueous effluents, the treating and dispersal of gaseous effluents, and limiting of personnel exposure to radiation. His major problems will be inplant and on-site. State health departments and other agencies concerned with air and water pollution control are currently in need of engineers and chemists capable of evaluating off-site or environmental radiation hazards. Here the solutions lie more in understanding the natural sciences related to air and water motion and to the chemistry and biology of soil, water, and air.

It is believed that the sanitary engineer, together with the chemist and biologist, providing they have received a nominal exposure to the radiological sciences, will function most effectively in the environmental area. The sanitary engineer can most expeditiously acquire the necessary knowledge by an education program at the doctoral level that builds on his competence in the waste and water fields and adds the radiological disciplines. Undoubtedly field experience and short courses, such as those offered by the U. S. Public Health Service, will continue to supplement advanced graduate education and will supply much of the personnel needs of the near future.

Professor Earnest F. Gloyna: At the University of Texas, the School of Engineering cooperates very closely with the Arts and Science Schools and in this connection, the nuclear program is spread out and administered by the various departments in engineering and science (see p. 127).

The radiological health program at Texas is considered a specialty course in the general area of sanitary engineering. Certain aspects of this subject are incorporated into all the required undergraduate and graduate sanitary engineering courses. The student could specialize for an entire program in nuclear engineering, if he so elected, but he would have to rely upon other departments for courses in radiochemistry, radiobiology, nuclear physics, reactor theory, etc. We only give one graduate course in radiological health engineering and this is offered to stimulate advanced studies.

The control of the environment is largely an engineering problem. It is not too presumptuous, therefore, to consider these problems in radiation control as one of the many facets to be considered by engineers. Yet the question arose several years ago, when we started this program, just as it arises now, why should a course or courses in radiological health be engineering?

Differences in opinion always exist when we talk about sanitary engineering, environmental sanitation, radiological health sciences, health physics, and so forth. The rapid development of these new scientific and engineering activities create situations leading to a tendency to band together. However, professional or even organizational splintering does not have to take place every time we run into a new environmental problem.

Traditionally engineers have dealt with problems in environmental health. These activities to a large extent have been under the covering umbrella of sanitary engineering.

With this background in mind, it becomes apparent that sanitary engineering, which is what we call it at the University of Texas, has taken some of the problems of radiation control in stride, just as our predecessors did in control of water and vector-borne diseases. The question is then answered as to why radiological health is included in engineering curricula.

When we began, we expected a few eyebrows to be raised from our own group. When you start a new program, you have to assure the other departments that you aren't stepping on their toes. We tied our program in very closely with the physics department and their nuclear courses, with the chemistry department and their courses in radiochemistry, with the zoology and biology departments and their courses in radiobiology, and so forth. As a consequence, we have exchanged students in many cases.

Radiological health engineering simply means a topic which warrants additional emphasis, similar to a special series in industrial waste treatment or air pollution control.

Upon careful analysis of all of our undergraduate and graduate courses, in sanitary engineering, one will find some information disseminated on radiological health. In our undergraduate program, all the civil and sanitary engineers have to take 5 semester credit hours of sanitary engineering courses; 6 contact hours are devoted to radiological health topics and 3 to laboratory demonstration.

On the graduate level, the scope is considerably broader. Student familiarity with radiological health problems is obtained through both formal course work and radioisotope-oriented research programs. This research program is one which is particularly oriented to the use of radioisotopes as tracers, etc. I want to emphasize this because participation in research is considered an important aspect in the graduate education program at our school, particularly since a large number of graduate students are employed as research assistants. Their work in the laboratory is faculty directed, and problem assignments are made in such a manner as to expose students to the greatest possible variety of problems.

One specific course in radiological health is given in the sanitary engineering program under the auspices of the civil engineering department. It is described as an analysis of radiation hazards, unit operations, and processes used in handling radioactive wastes, development of shielding concepts, decontamination, radioisotope identification, dosimetry, and principles of detection devices. Most sanitary engineering graduate students, both masters and Ph.D.'s, and a number of the advanced science students take this particular course.

Currently this course breaks down something like this: In the lectures: Review of atomic physics and principles of detection, about 30 percent; interaction of radiation with matter, 20 percent; radiation exposure and shielding, 20 percent; and waste handling and disposal, 30 percent. In the laboratory: Two equal phases; 50 percent on principles of radiation detection which includes G.M. counter characteristics (15 percent); data reduction and statistics (5 percent); proportional counting systems (15 percent); principles and use of electrometers (5 percent); liquid and solid crystal scintillation techniques (10 percent); and 50 percent on waste handling, which includes chemical precipitation and tracer tests (10 percent), ion exchanges and fixation (10 percent), microbiological uptake and retention (10 percent), air sampling and cleaning (10 percent), and shielding problems (10 percent).

A modified version of this course is offered and given to practicing physicians, radiologists, interns, and some medical students, without the integral science. The material presented to the medical people is more descriptive, using a minimum of mathematics. Also, emphasis is placed on interaction of radiation with matter and dose calculations, rather than waste handling.

There is one interesting observation. We tried to operate the laboratories in the same manner for both groups and this didn't work. We found that engineering students and science students wanted to get their hands on the equipment -- they wanted to operate it themselves. So we set up entirely different techniques. The engineering and science students do the experiments; medical students merely get demonstrations.

If a student wishes to specialize or direct more of his academic time to nuclear problems, there are 14 additional nuclear-related courses. These are about equally divided between the Colleges of Engineering and Arts and Science. These course offerings, together with special topics, laboratory work, and the research effort, are a package.

In graduate research, certainly most of our students in sanitary engineering do not complete a master's program in 9 months. This is because most of them are on a part-time research assistantship. These assistantship students may not be working on a thesis topic directly but their assignment is considered to be a form of classroom supplementation. The student's performance is closely observed and when it appears that he has progressed to the point where his work is routine, he is given a new assignment. In some respects this practice may decrease the efficiency of the research but we don't consider ourselves a research corporation, so we overlook it.

Meritorious though it may be for professors to discuss research on the master's level, such efforts are not likely to bear fruit unless the contributors are part of a well-balanced research team. In this respect, the extended laboratory education is of particular importance to those wishing to learn more about the solution of problems involving radiological health. In any case, departments who have equipped their laboratories with radiation detection capabilities have found a truly powerful "tool" in the radioisotopes.

One thing I'd like to mention here is that since we consider this as a package effort, one of the big bugaboos in the radiological health program is the cost of equipment. I think it soon becomes apparent that the unit course cost in radiological health is rather high. The basic detection equipment required for an adequate presentation of subject material in radiological health is estimated to cost as high as $50,000. The annual operation and maintenance cost may be as high as $2,000. To the university administrator, it soon becomes clear that the cost per student for radiological health is higher than the ratios computed on a similar basis for other courses.

As a matter of fact, it is very doubtful whether a school should attempt to offer courses in radiological health engineering if it does not intend to complement the formal classroom effort with research effort using tracer and similar techniques.

In the first place, school administrators are reluctant to equip a complete radiation detection laboratory for such a specific subject as radiological health. Second, radiation detection equipment, and most electronic gear, does not function at its peak capacity if used only during a specified laboratory period scheduled once per semester.

Although subjects in radiological health are considered to be expensive undertakings, this does not mean that a school or laboratory cannot take advantage of the "tool" aspects of the radioisotope at a reduced total cost. Suitable single-purpose detection equipment can be purchased for $5,000 or even less.

Dr. Marvin L. Granstrom: As a matter of convenience, the expression "radiological health" is used as a generic term here, to indicate courses or programs which include some environmental aspect of ionizing radiation.

This particular topic, that is "Integration of Radiological Health into the General Engineering Curricula," is most appropriate and timely at this symposium because at the American Sanitary Engineering Intersociety Board Study Conference on the improvement of graduate curricula for sanitary engineers, held at Dunster House, Harvard University, Cambridge, Mass., June 27-29, 1960, and attended by about 120 sanitary engineering educators and others, it was recommended that all graduate sanitary engineering and other similar environmental health engineering curricula in this country include instruction in radiological health. No attempt was made there to describe the content or extent of instruction in radiological health; however, I assume that the general consensus was the minimum instruction time should be about equivalent to a 3-hour 1-semester graduate-level course. If this recommendation is carried out by the various colleges and universities which offer graduate programs in sanitary engineering, air hygiene engineering, public health engineering, etc., the future graduates of such programs will be more aware of and better trained in the field of radiological health than are many of the present practitioners.

My purpose is to describe the present programs in radiological health in the general engineering curricula. With the exception of programs in nuclear engineering, including such topics as nuclear hazards and safety, and health physics programs, which are not essentially engineering programs, the majority of radiological health training for engineers is in the curricula for sanitary engineers. Thus I used, as an initial source of information, the "Sanitary Engineering Education Directory" published by the American Sanitary Engineering Intersociety Board, located in Room 1601, 33 W. 39th St., New York 18, N. Y. This publication is a compilation of information supplied by colleges offering graduate work in sanitary engineering, schools of public health, and instructors in sanitary engineering courses in schools or colleges not offering graduate programs in sanitary engineering. The information is quite current.

Included in the directory is a roster of instructors and the courses which they teach and their areas of research. Note was made of the institutions in which faculty members designated radiological health as part of their teaching programs or as part of their research. The catalogs of these institutions were studied and the information gathered was tabulated. In one of the tables was listed the names of the institutions, the number of special courses in radiological health, and the number of instructors in teaching and research in radiological health. The other table included so far as possible another number and title of the special courses in radiological health in each of the several institutions offering such courses. The information contained in college catalogs is not always current or complete so some additional information was gathered from delegates at this symposium.

I find that there are about 30 sanitary engineering professors other than those in schools of public health who include teaching of radiological health in their courses. There are 16 special courses in radiological health offered in colleges of engineering, primarily for sanitary engineers. There are several courses in the regular curricula in which some instruction in radiological health is included. There are special programs in colleges of engineering with major emphasis on radiological health.

Within schools of public health which are located in institutions which also have graduate programs in sanitary engineering or which have graduate engineers as students, I find that there are about 25 instructors teaching 27 courses in radiological health in which graduate engineers may enroll. There are 4 special radiological health programs in schools of public health for those concerned with environmental health, including engineers. In almost every institution, there are supporting courses in such areas as biology, chemistry, physics, and, in some places, programs in nuclear engineering. The extent to which these supporting courses are required or used is not clearly defined in the various college catalogs.

Thus it is immediately apparent that the field of radiological health has not been neglected. However, to those persons who are most aware of the problems in radiological health, it appears that the extent of training of personnel is not sufficient to meet the needs.

It is quite likely that there will be an expansion in radiological health training programs in universities for engineers and others. Some of you will be creating or expanding programs to meet these needs. I believe that the planners for this symposium expect the speakers to relate some of their own experiences, as well as those of others.

I should like to describe my experience in teaching a 3-hour 1-semester graduate level course and also my experience in teaching radiological health topics as small segments of other sanitary engineering courses (see p. 132). My experience and that of others in teaching one complete course to engineers has been good. The teaching, at least at the basic level, has been enjoyable. Most of the students have had some instruction in atomic and nuclear physics in their sophomore physics courses and the mathematical treatment of such things as decay, equilibrium, counting statistics, etc., has been readily understood. We realize that many of the students have not received formal instruction and so about half of the lecture portion of the course is devoted to fundamentals. The other half of the course is devoted to general descriptions of techniques, situations, processes, and problems.

The greatest deficiency in the sanitary engineering student's background is physical chemistry. The concepts of solvent extraction, co-precipitation, crystal formation, and the like, are completely lacking. Treatment of the topic of radiation biology is cursory but sufficient to make the student aware of the seriousness of the problem. An essential part of any such course is the laboratory; it need not be extensive but should include the basic survey and laboratory counting instruments, and facilities should be available for sample preparation.

My own experience in teaching certain topics in the field of radiological health as part of other courses, to students who have not had a fundamental course, has not been too good. The treatment is necessarily so cursory that the instruction is almost purely descriptive. However, if appropriate topics were included in several of the 6 to 10 courses in the master's program in sanitary engineering, the program could be quite a bit improved. Also I have had students attend conferences and seminars when such were conveniently available.

It is possible to provide instruction in radiological health in the sanitary engineering curriculum. My own opinion is that there should be a minimum of one 3-hour, 1-semester course on fundamentals, techniques, and description, followed by application in other courses. Also I feel it should be emphasized that radioactive exposure and general contaminants are not just another industrial hygiene or industrial waste problem. The semi-permanence of the pollution and the critical genetic effects are not to be treated casually.

With the anticipated expansion of general and intensive training in the field of radiological health, I should be remiss if there were not an expression of my opinion and those of my colleagues at Rutgers. My comments will be limited to engineering training; however, the concept should be applicable to other areas of specialty.

There might be a need to create a 1-year intensive curricula in the field of radiological health for holders of the baccalaureate degree in engineering. This would be an adaptation of the several health physics programs currently being conducted. The graduate of such a program would be a very well qualified technician to whom limited responsibility could be assigned. On the other hand, such a curricula combined with the current type of masters programs in sanitary engineering more likely would yield a graduate with considerably more breadth of knowledge and comprehension. A graduate of such a combined program would be both a sanitary engineer and a radiological health specialist. Of course an experienced sanitary engineer with or without a master's degree could take the 1-year program to become a specialist. For further education and training leading to a doctorate degree, there would be an intensification of courses in a more limited area, such as physical- and radiochemistry, to be followed by an appropriate research thesis.

I know that many of our colleges of engineering are ready to provide the training and education to meet the future needs in the field of radiological health.

Dr. Leslie Silverman: Those of us who have been in the industrial hygiene field for several years have been concerned with problems of radiological health for a long time. I think we can claim that significant radiological health problems existed before 1940 and well before the days of the Manhattan District. We were concerned with the mining and refining of radium and thorium and with radon and thoron problems in the mantle industry, we encountered problems with X-ray exposures in industry, with the use of radium capsules for casting inspection, with exposures from other nondestructive testing by various machines such as cyclotrons, fluoroscopes, electron microscopes, and we even had betatron problems before the Manhattan District was established.

We were concerned with these exposures as they occurred in various occupations. We did not have as much concern with the community because, unless somebody took a radioactive capsule home which occasionally happened, it did not get into the community very often. But nevertheless we did have interest in these problems and educated our industrial hygiene engineers to the fact that evaluation of radiation exposures in industry would be a necessary component in their experience.

With the great emphasis and interest in nuclear applications, nuclear engineering as a field has become even more attractive than radiological health.

I am disturbed, of course, by the fact that nuclear engineering has become so attractive. I want to dwell on this a little bit because this is where I think some integration in curricula can occur. Nuclear engineering programs and courses have been set up in over 30 engineering schools and other institutions and along with this has come a nice little package of $250,000 towards the purchase of a reactor -- a training reactor or a teaching and research reactor. These are no longer available because they've sold all 30 options!

Also, a program has been set up and supported by the AEC for training students in a field described as nuclear science and engineering. A large number of fellowships have been made available. It is very interesting to note that last year 270 fellowships were awarded. Of these 270 fellows receiving subsidies for tuition and support, nearly 90 percent are going to 4 institutions with programs in nuclear engineering. So you can see what's left for the other 26 institutions.

I'm afraid that we face this same problem in teaching radiological health within sanitary engineering programs. The number of institutions offering programs in sanitary engineering may actually exceed the number of students. This would be rather disastrous for at least one institution.

With these facetious comments in the background, let me get down to cases. I shall discuss what we have tried to do at Harvard in the industrial hygiene teaching field to integrate radiological health into our curriculum as well as to orient public health people in the problems we face in radiological health.

It seems to me that one of the things to be considered is how much faculty time and what kind of personnel facilities can be devoted to radiological health. In setting up an acceptable recommended program for industrial hygiene training under AEC support, it was decided that the schools should have at least three full-time faculty members assigned to the program. They also recommended that the teaching or course load should be reasonable, say not more than 10 to 12 hours a week. Some of you may welcome this statement.

Radiological health programs can and should be integrated into air hygiene and industrial hygiene programs as indicated in our Dunster House discussions in Cambridge last June.

There is a program in nuclear engineering at the Massachusetts Institute of Technology (MIT) in which radiological health problems, the handling of radioactive materials, and all of the problems in protection of personnel are integrated into a graduate degree program in nuclear engineering. Almost every student who takes the program takes this course. MIT is one of the four institutions I mentioned which have 90 percent of the subsidized students, hence it's not an inconsequential number of persons now receiving this integrated instruction.

I think that such integration should and will continue. It's a necessary adjunct to nuclear engineering. You cannot separate the man who is concerned with the design and brings to fruition the complete operating reactor or nuclear handling facilities, from the problems of handling the materials and protecting the operating personnel.

This aspect of integration is the contribution that we should be making in the engineering schools, call it sanitary engineering or radiological health engineering or industrial hygiene engineering, whichever you please. A program in nuclear engineering is the place to point out the problems in radioactive waste handling and disposal, exposures in use of hot cells, and caves, and personnel aspects of dosimetry and measurement of exposure.

As far as a health oriented or environmental program in schools of public health or departments of sanitary engineering is concerned, we have a program at Harvard which is a cooperative one operating under the aegis of the School of Public Health and with the cooperation of the Graduate School of Arts and Sciences' Division of Engineering and Applied Physics (see p. 108). We do have courses in nuclear engineering in the division although we do not have a formal program to a graduate degree in this field.

We cover subject areas which include in all of its ramifications the theory and principles of radioactivity, its measurement, and its effects on man. To do this, we must give the students some background in human physiology, and a course in toxicology and radiobiology. After all, radiation biology and toxicology really can't be separated because the interaction of matter due to radiation produces some toxic products by this interaction. So we call our course toxicology and radiation biology.

We have a course designated as radiological engineering which includes the problems of site selection, of meteorology as related to doses off-site, of problems concerned with gaseous and liquid waste handling in certain operating areas, and emergency planning.

Problems associated with radiochemical processing are recognized as the most hazardous. (I would prefer to be concerned with five reactors compared to a good size chemical processing plant, as a problem.) There is some emphasis necessary in this program, on the kinds of chemistry involved in radiochemical processes and the steps involved. These must be related to waste treatment, of course, because all chemical processing produces waste which causes our real concern in the long run, in applications of nuclear energy for power production as well as for other purposes.

We feel that those engaged in radiological health as well as other health work must have some concept of biostatistics and epidemiology because the effect of the environment on man must be considered from a statistical viewpoint. Our program is offered on a 1, 2, or 3 year basis, depending upon the interest and the degree of specialization wanted, with some emphasis being placed on the technical background of the student.

Engineers who have a master's degree in engineering can enter the School of Public Health and receive in a year a Master of Science in Hygiene with specialization in radiological health and allied courses. We don't give the Master of Public Health degree to engineers at Harvard. What we're trying to do is train engineers to work in the various special fields in public health, but they do not have to have a public health label as such after their names.

We also have an almost parallel program which operates through the Graduate School of Arts and Sciences. A man with a bachelor's degree in physical sciences or engineering can receive in a year a master's degree with emphasis in the radiological health area. He certainly doesn't leave this program without knowing a lot about other facets of the environment. We want to be sure that people that work with problems of the environment have a general recognition that there is more than radiation involved. At Vanderbilt and at Rochester, some limited course work is given in industrial hygiene in addition to their health physics work. It all depends on your original orientation whether or not you put greater emphasis on radiation and less on the environment, or vice versa.

In implementing programs, our real problem today is recruitment. The engineering profession is suffering from decreased enrollment because of the glamour of missiles and rockets. Nuclear reactors get a little of that glamour and deprive us of people interested in protecting man by controlling the radiation in his environment. We still have to fight hard to get people interested in what has been described as a service profession. While it is a pretty important service as far as I'm concerned, nevertheless we do have a problem in obtaining well qualified graduate students. I think there is much that could be done in the recruitment area.

I would also like to emphasize that all these should be graduate programs. I do not think there is any place in the undergraduate curriculum for specialization. A basic program in science and engineering is where you start and from then on, you build. I'd rather see a good foundation on which to build than a flimsy foundation with a pretty good roof. The roof isn't going to last long if the foundation should crumble!

Schools of Medicine

Dr. Richard H. Chamberlain, Professor of Radiology, Hospital of the University of Pennsylvania, Chairman.

Dr. J. N. Stannard: The title for this discussion probably should read "Experience in teaching radiological health in a medical center." My remarks will concern primarily our experience at the University of Rochester School of Medicine and Dentistry (see p. 124). The curriculum as it exists at Rochester represents an attempt to weld the needs of a medical school faculty and student body and a medical center environment with the special needs of the Atomic Energy Commission's health physics fellowship program and a broader academic experience in basic research and in related areas of radiological health.

Historical Development

It is quite obvious, of course, that the program developed at Rochester primarily because of the prior presence of the Atomic Energy Project at the University. Therefore, I would like to describe very briefly the history of its development.

During the war years, there was, as many of you know, a concentration of biological and medical research under the Manhattan Engineer District in Rochester. This was at first administratively connected with the Department of Radiology and later as a separate entity operated as a wartime "project."

After the war, when the Atomic Energy Commission was organized and control of the project became the Commission's responsibility, it was clear that Rochester was a logical place to institute graduate level training in this emerging new field. The staff was academically oriented and the Rochester project was physically located within a University.

It was originally planned that the program would be largely post-doctoral with emphasis on research experience and preceptorship type training. But by the time the facilities were ready, the Korean war had started. The numbers of physicians and others (e.g. service officers) available to enter postgraduate training declined sharply. At the same time, the fellowship program in health physics began and Rochester-Brookhaven and Vanderbilt-Oak Ridge were chosen as the original training centers. Thus the program was populated for many years mainly by students with a bachelor's degree in science or engineering who enrolled for 1 year of instruction in this area. Degrees and an academic type organization prevailed from the start, however. Many students remained for further work. Many came for Ph.D. work through other channels.

General Organization

Today, we offer a Master of Science and a Ph.D. degree in the field of biophysics and of radiation biology (see p. 124). Details of requirements and of philosophy are given in the Bulletin of Graduate Studies. Students working in health physics and related fields (e.g. hospital physics or radiological physics) usually receive the degree in radiation biology. However, the degree and program are always flexible depending upon the background and interest of the individual concerned.

Most of the 1-year master's degree candidates use the so-called Plan B, which is a degree without laboratory research but with a comprehensive examination and essay requiring the completion of 30 hours of graduate level work with a grade of B

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or better. Some take a somewhat longer period and complete the M.S. under Plan A, the more conventional program with research and a thesis based on experimental work.

Recently the group in radiological health has been swelled by addition of the "Advanced Course in Nuclear Science for Medical Officers" sponsored by the Defense Atomic Support Agency (DASA). This utilizes the same core subjects as the health physics curriculum but is tailored to the needs of medical and medical service officers. It is less rigorous in physics and mathematics, more demanding in biological and medical areas. Several PHS officers are now taking part in this and closely related programs.

In addition, there are informal offerings such as short courses and traineeships and collaborative or joint programs. One of these is in industrial medicine. This is essentially a post-doctoral curriculum. It was organized several years ago, largely through the efforts of Dr. James Sterner, medical director of the Eastman Kodak Company, in response to the wide-felt need for physicians in occupational medicine with a clear orientation to the problems of nuclear energy. A Master of Science degree is offered under Plan B. This curriculum is a joint operation between the Department of Radiation Biology and the Department of Preventive Medicine and Community Health, aided by considerable contributions of time and staff from Rochester industries.

More recently we have formalized two other areas of collaborative effort. One is for training in hospital physics. This is accomplished in collaboration with the Department of Radiology. The student is registered in the Department of Radiation Biology but does a good deal of work with members of the Department of Radiology in the area of hospital physics. This provides enough practical experience and formal training to meet the requirements of the American Board of Radiology for the diploma in radiological physics. The other area is a collaborative effort in the opposite direction; *viz*: to enable residents in radiology to obtain research experience and courses in basic radiobiology. Such individuals can register for certain courses in the Department of Radiation Biology, do research under the guidance of a staff member of either department, and receive a master's degree with about 1 year of work added to the regular residency requirements.

Support for all courses in the Department of Radiation Biology stems from the Atomic Energy Commission's contract with the university. In view of this support, the department does not charge tuition. There are tuition charges for courses offered and taken in other departments, with the exception of industrial medicine since this has operated in close conjunction with radiation biology and support from industry is so considerable that tuition charges could hardly be justified.

Finally, there is close collaboration with the Department of Biology in the College of Arts and Sciences, particularly for discussion and instruction in radiation genetics. There is similar cooperation with the College of Engineering for a short course in nuclear engineering.

Curriculum and Student Body

Let us now turn to a few details regarding student body and curriculum. We try not to establish a standardized curriculum on general grounds. I doubt if we could even if we wished, because we deal with a very motley group (if I may use the expression). The health physics fellows are primarily physicists but the group includes some biologists, some chemists, some engineers. The DASA group includes physicians, veterinarians, pharmacists, an optometrist, and one physicist, from the three military services. The Public Health Service officers are physicians, veterinarians, or pharmacists.

Obviously, the objectives of these different groups are quite varied. The Public Health Service officers may be anticipating duties in radiological health as applied to the general population. The Air Force officers may be anticipating assignments in the area of nuclear aircraft, rockets, or nuclear weapons effects. The Naval officers may be oriented primarily toward the nuclear submarine service. (Most of the medical officers now aboard nuclear submarines have been through Rochester one way or another.) The students from abroad may be learning only a little about health physics as an incidental to their plans for constructing reactors. Others, and this constitutes the majority, expect to have major responsibilities for radiological health in the nuclear energy enterprises of their home country.

Some features of the curriculum require further comment:

1. We adhere strongly to the point of view that radiation protection should not stand as an entity unto itself with chemical hazards essentially neglected. We urge all students in the program to take both industrial hygiene and toxicology if they have not had some basic training in these areas previously.
2. Students in the health physics curriculum who have not had biology take the 6 hours indicated on "Biological Effects of Radiation." In the first semester, they should elect "Basic Radiobiology." Those who have studied biology should take only the second semester portion.
3. The electives indicated may be replaced by reading courses in areas of special interest. This is done by adding 2 hours to the program.
4. It has been found advisable to operate sections of the seminar courses for those with different interests.
5. The physicians and veterinarians usually elect a course in clinical radiopathology given in the Department of Radiology. This brings the total credit in biological effects to over 6 hours. Many also elect a course in clinical radioisotopes given in the same department.
6. A seminar in epidemiology is being added (1960-61) for the Public Health Service officers and others interested.
7. The course in radiological physics taken by the health physics fellows is much more rigorous than that taken by those trained primarily in biological science.

You will recognize that we are working with a group divided about equally between people trained in the physical sciences and people trained in the biological sciences. Also, it is similarly divided between students who have come directly from college and others with varying degrees of experience and maturity. This requires not only flexibility in scheduling but many quite special courses. For example, we must give elementary biology in a form palatable to physicists and pertinent to future courses.

But particularly we have found need for a dedicated, patient, and understanding faculty of sufficient size to meet the many special needs without undue burden on any single individual. The only alternative is a considerable lengthening of the term of study to allow the attainment of a more uniform background before undertaking radiological health studies.

The curriculum for the Ph.D. in radiation biology may use the first year as a base or accept students directly. In any event, the usual program will fall in the ranges shown. Obviously, much emphasis is placed on specialty seminars and research. While the formal courses do not constitute a clear "major" in one of the conventional biological sciences, it usually turns out that the dissertation research requires considerable polarization. Thus, the student is usually prepared in essence for teaching and/or research in one of the basic medical sciences. Radiation biology is his special interest but not his only capability. He is expected to be identifiable as a physiologist, pharmacologist, biologist, etc., even though he must also be able to handle radiation physics in reasonable fashion.

The Ph.D. in biophysics differs primarily in requiring a knowledge of physics through quantum mechanics and wave mechanics. Dissertation orientation is largely toward radiation biophysics. However, other areas are open, particularly for collaborative work with the Department of Biology, Physiology, the Institute of Optics, etc. These are also described in the graduate bulletin.

Staff and Costs

There was some interest expressed in cost figures in the preliminary planning for this meeting. Such figures are difficult to calculate for the Rochester program. Only a small fraction of the total educational expenses are budgeted separately in the Atomic Energy Project. There is a budget for laboratory assistants, for equipment and supplies for teaching, and for the salary of the director for education and a secretary or two. All other costs are contained in the research program budgets.

Nevertheless, I will make an attempt to estimate the direct costs. There are 25 staff members who play a significant role (approximately 40 percent of their time) in the teaching program. Then there are another 25 who give lectures or aid with one or more laboratory experiments. Another 25 come in for perhaps one lecture each. If we multiply the number of individuals contributing by assumed fractions of their total time, we come out with approximately $100,000 a year as the necessary operating budget for direct costs. This is low since it requires the presence of the Atomic Energy Project as a baseline.

At the present time there are 52 graduate students registered for credit in the Department of Radiation Biology. There are enough others on an informal basis to bring the total student population in the department to about 75. Counting all of the people concerned with the program, we thus have a one-to-one ratio between instructors and students. If we consider only those who either have charge of a course or are involved quite significantly, we find a ratio of about 3 students per instructor. This is quite favorable but is none too much for a program of such breadth and variety.

Problems

Some specific problems we have encountered should be highlighted.

1. The first is the breadth of the field. So frequently it is necessary to touch rather lightly in certain areas that specialists sometimes find teaching the first year group rather frustrating. Only those who have been through a program of such breadth themselves can appreciate that this places a challenge on the student quite equal to that of more conventional fields. Thus much specialization has to be deferred to Ph.D. program seminars and research. The first year requires staff who are themselves thoroughly interested in radiological health problems and familiar with the broad aspects of the field. An institution's staff without such interests will not be likely to do a competent job nor would it find much intellectual reward in trying to institute a training program in this area.
2. Dr. Anderson mentioned yesterday the problem of recruitment. We believe that the Health Physics Fellowship Program is somewhat on the horns of a dilemma regarding recruitment. Announced and emphasized as a 1-year terminal program, it frequently repels able students who might go far in the field. Any university entering the program as a training center is going to want good students and seek those interested and capable of Ph.D. work. Also, the field needs more and more senior men as it grows. These should be the primary interest of the university centers.

   Yet the Congress stipulates that AEC Fellowship funds are to be used primarily in areas of direct application to commission problems. If the problems are narrowly defined, the fellowship program is indeed in a dilemma. I submit that it is impossible to tell before the end of at least 1 year which way is best for a given individual. Some should begin their contribution in industry or government immediately. Others should go on for more advanced work. Those most capable should not be discouraged away by the terms of an initial fellowship.

   Some alteration of this restriction is needed or clearly some other sources of fellowship funds should be available to carry on. The only AEC support for additional work at present is through the special advanced fellowship in health physics for individuals who have already had some years of experience in the field.

   If something could be done to increase the total number of applicants for the program and to broaden support, without in any way getting into difficulties between the purposes for which the AEC allocates its funds and the purposes of the program from the academic point of view, we might be in less of a dilemma.
3. In general, trying to do as much as is needful in 1 year takes on many of the characteristics of a "rat race." The students are very tired at the end of the year. We have to remind them continually that it will all make sense by the end of a summer session at Brookhaven, and frequently it does! We feel we are making progress. However, 2 years would be a much more satisfactory time for basic radiological health training at the university level.
4. The program at Rochester needs special strengthening at two points.

One is in the field of epidemiology. This is given now in the industrial medicine curriculum, and by a special seminar this year. The average person seeking a degree in radiation biology at Rochester now has little exposure to the basic problems in epidemiology. Those aiming primarily toward epidemiology might find it better to enter a school of public health. The other area is genetics. I do not think we yet have enough time to properly present the problems of radiation genetics. It is postponed largely to later studies and is sometimes neglected.

Final Comment

From this discussion, you can all appreciate readily that programs bringing together physicians and first year graduate students with a background in physics requires a certain amount of tightrope walking. We think we have done a moderately good job with the devices described, but we see many ways that we could and would like to do better. A more homogeneous student body would simplify the problem but it might not be as interesting. The varied program described is possible at Rochester by the presence of a large and interested staff. We would like to continue with especial emphasis on senior people. However, now we begin to look forward to many of our graduates taking an active part in extending the training required to the increasing number of individuals needed in radiological health activities.

As a footnote, I would like to mention the AEC Equipment Grant Program. As you know, equipment for programs in radiological health is quite expensive and funds are frequently difficult to obtain. The equipment grant program of the commission is playing a very important role in supplying laboratory equipment for these purposes as well as for basic radioisotope experiments in a variety of institutions of higher learning. However, there have not been requests from many schools that might be able to use such funds for establishing radiological health training. Combined with training grants, these funds might possibly help overcome some of the major obstacles to proceeding to the aims described in this symposium.

The greatest obstacle remains, however, the availability of suitably trained staff. The provision of such staff should be one of the prime objectives of university programs.

Dr. H. Stephen Weens: As a physician I am naturally interested in the very best radiological health education of physicians. Many efforts are being made to improve the training of our radiological health physicists but I am a little worried that the radiological education of physicians is often forgotten, particularly in the undergraduate medical education program.

This is important for the following reasons: Whatever we teach today will have an impact 10, 20, and 30 years hence. If we create individuals whom we may call radiologic specialists or health physicists, then we have to have a counterpart in the medical field, a physician who is motivated to accept their scientific opinions and work with them. If we do not have this counterpart, there will be failures. No matter what you try to accomplish, you will fail in your projects unless physicians understand these problems and collaborate with radiologic physicists and health specialists.

It is obvious that a medical school can enter the field of radiological health education in various areas. We have the problem of undergraduate education as well as the problem of graduate education in the resident system. Here I would like to stress, and this is very important, that only part of the entire residency system in the United States is under the direction of medical schools. There are various large resident programs which are completely disconnected from medical schools. The same applies to the education of medical X-ray technologists. Then there is the training program of radiological specialists or radiological health physicists which we will discuss later on as far as our own institution is concerned.

It will be the task of future medical education to recognize these various areas. For the sake of simplicity and brevity, I will confine my remarks here to some of the problems which we have in the education of medical students and some projected programs in the education of radiation health specialists as well as the impact which these programs will have on the overall design of the medical school curriculum of the future.

In the medical undergraduate program, the question immediately arises, "Who should organize a program of this type?" Obviously, there is no uniform answer. It depends upon the establishment of special departments of biophysics or nuclear medicine in the medical school, and it depends upon the interest of the department of preventive medicine as well as the aims of a department of radiology. Radiologists are vitally concerned with the problems of radiological health and protection. From the standpoint of a radiologist, I feel that most medical school departments of radiology should be willing to accept the responsibility of developing an adequate educational program and seek the necessary support for its implementation.

Everyone in the field of medical education has a firm obligation to look beyond the scope of his own field of interest. If we do not realize this there is no need to discuss a medical school curriculum here. Many of us, sooner or later, will be faced with this task. It is a difficult and sometimes ungrateful task and occasionally the chairman of the department of radiology will be charged with this responsibility.

The conventional medical school curriculum has an overcrowded schedule. How can a new block of teaching time be squeezed in?

There are many periods in the first 2 years of the medical school curriculum (in anatomy and physiology) where there are opportunities for exercises utilizing radiologic methods. Should efforts be made to present the entire subject matter of radiologic health at this particular time? I am quite sure this would be feasible in some schools and perhaps desirable in our own school. We believe, however, that it would be better to postpone such an organized effort to a later period of time, such as the last part of the third year and the fourth year of medical school.

In the third year of our medical school curriculum, we provide a series of lectures which may be described as introduction into radiology (see p. 132). Some nine or ten of these deal with the physical characteristics of radiation, with the interaction of radiation with matter and some of the problems of radiation protection. These lectures are given consecutively five times a week at the termination of the junior year followed by an appropriate examination.

This introduction to the subject matter is followed by a clerkship in radiology in the senior year. This is probably different from many other medical school programs inasmuch as this is not an elective clerkship. All medical students in our school participate in this program. It lasts for a period of 3-1/2 weeks during which time the medical student is on a full-time basis assigned to our department.

Many years ago this clerkship or radiologic course was largely devoted to radiodiagnostic problems and the field of radiotherapy, including the presentation of radioisotope medicine. Recently, more and more of this program familiarizes the students not only with the clinical applications of radiology but with fundamental problems and teaches them the role radiation plays in the medical and non-medical environment.

During this clerkship there is ample time in group conferences to review elementary radiation physics. There is instruction in practical dosimetry. The student not only sees simple radiation dosimeters but has the opportunity to acquaint himself with these instruments by using them. The problems of radiation protection are discussed at the same time. In radiotherapy the student not only observes the clinical operation of a radiology department but learns to recognize normal radiation reaction and is instructed on the biologic effects of radiation.

As the medical students are entirely at our command except for daily hospital conferences, there is opportunity to fully utilize the teaching time to advantage. Our classes consist of 72 students or 8 groups of 9 students.

A combined program has been devised by our department and the Department of Physics at Emory University. This has directed our interest to the research program and education of undergraduate and graduate students in physics. In an informal way we help to educate individuals who have entered the field of radiologic physics or related disciplines. This combined program has led to the training of radiologic health specialists at the master's level and an active radiologic health physics program in our institution. We envisage a 2-year program of radiologic health physics which will lead to a Master's degree. It will feature an apprenticeship-internship period of approximately 6 to 8 months in the clinical radiology departments of our associated hospitals, in the clinical isotope departments, and in the University's radiation safety office.

It has been stressed repeatedly in this conference as well as in other conferences that medical radiation exposure plays a very significant and substantial role in the overall total radiation exposure of our population. Our aims are more or less directed toward the training of individuals oriented to those aspects of radiologic health which pertain to all phases of medical radiology and the problems arising in connection with the surveillance program of a State health department.

We project also a training period in the industrial hygiene division of the State health department and a period of training in the reactor facilities available in our own area. A solid program in graduate level physics including nuclear and radiation theory and introduction to human anatomy and physiology should enable the individual to obtain the respect of the medical personnel with whom he must deal.

This training program should be carried out by the graduate school and staff members in physics, anatomy, biology, biochemistry, and physiology who would assist the radiologic staff in this endeavor. It would lead to the degree of Master of Science for those who complete the program or otherwise satisfy the requirements of the graduate school.

At this time it is confined to those with previous education in physics but I would like to point out that this is not a rigid program as we envisage it. It must be geared to the previous education of the students, which varies a great deal.

In this 2-year program, the student will gain first hand experience in the problems encountered by medical and public health personnel who are engaged in the surveillance of institutions using various types of radiation sources, including medical X-ray equipment. In order that the trainee will be thoroughly familiar with these problems as well as the traditions and working habits of the medical profession as they relate to the use and control of radiation sources, the internship program in the hospital and public health laboratories is considered to be an essential part of what we propose.

In the study assignments in the hospital, there will be ample opportunity to participate in the solution of various radiation detection exercises and the general surveillance of the radiology department.

Also at this time, the students gain firsthand experience in the medical X-ray technology educational program. In the radiotherapy and isotope divisions, the student will attend treatment planning conferences, see how radium applicators are being prepared, and learn all about radiation protection problems in orthovoltage and supervoltage therapy. A period of time will be given to participation in the work of our research and clinical isotope laboratories. They will not only learn about radiation health problems, but also study the necessary administrative procedures of these laboratories.

In the State health department, the student will have a splendid opportunity to acquaint himself with practical problems of determination of air pollution and water pollution. Under this training program, the student obtains some instruction in the practical administrative problems of radiation surveillance of medical installations from the viewpoint of the public health organization.

And, finally, it is anticipated that in some of the existing as well as developing reactor facilities in our area, there will be opportunity to study industrial radiation protection.

We believe that there are many benefits which may be considered as byproducts of such a training program. The presence of trainees in the radiation physics division of a radiology department and the active participation of the entire staff in this educational endeavor call attention to the role of the radiologic specialist in the medical community. Medical students will find courses in radiology and preventive medicine enriched by the presence of this program.

The integration of this program with the activities of the department of radiology and physics should assure the trainee a splendid opportunity to participate in some of the research currently active in these divisions. He will also gain practical teaching experience in those instructional programs of the department of radiology which relate to the education of resident physicians and training of X-ray technologists. These two phases of experience — research and teaching — appear to us essential.

At this point, we can only emphasize again that the program we anticipate displays from the very beginning the close relationship between members of the medical profession and the radiation health specialists — a relationship which appears a prerequisite for the successful development and operation of any radiologic health program. The very close collaboration of a department of radiology with the college department of physics offers an excellent opportunity to effect a better correlation of medical and premedical education.

Dr. William T. Ham: Why should medical schools teach radiological health? I am sure everybody in this room feels that they should, but it still seems to me that it is a good question to ask. In thinking about it, one thing came to me. I remember a very able address given by Dr. Shields Warren before the Health Physics Society in Boston. If I understood him correctly, he made a plea that the medical profession be allowed freedom; that legislation not be hastily drawn which would deprive the doctor of his freedom and his incentive to do things. But with this goes a moral obligation and I was questioning all during his talk whether the medical profession actually lives up to this demand.

As they stand today in this country, many medical schools do provide what we call here an elementary, rudimentary radiological health education, but I think one must say that many of them don't. Medicine does have a moral obligation to introduce into the medical curriculum somewhere and in some way at least an elementary education in radiological health.

But there is another good reason for it. It is of self interest to the doctors, when they consider the tremendous help that radioisotopes can be in diagnostics and certain types of therapeutics. The stimulation that radioisotopes have given to research in metabolism and precursors of metabolites has been one of the greatest known.

The medical school does have an obligation to teach radiological health, but where should it be taught? I believe it should be taught during the 4th or the 5th year of the medical curriculum. If it isn't taught at this period, we will be graduating into the world M. D.'s inadequately prepared to deal with radiation hazards.

Those that are graduated present other problems. Many of the States now are licensing X-ray machines. This has been done in the State of Virginia recently, although we haven't decided as yet just how far our powers go. You can catch some of the troubles that have arisen already in this way. Lots of others can be caught by the radiologists and the various societies in their public campaigns.

But primarily we should think about stopping trouble at its source, namely in the medical school. In this connection, I too would emphasize that the resident program is not under the control of the school.

Medical schools should teach elementary radiological health (see p. 130). What about the content of this teaching? At the Medical College of Virginia, there is a course which we call radioisotopes. This course was started to try to give medical students, practicing physicians, clinicians, and our own faculty in the local area of Richmond the basic physics which would allow them to apply for an AEC license. This course is only designed to supply the basic aspects of radiation physics.

The program has been rather successful. This past year, we had 32 people enrolled. Of these 32, 4 were Ph.D.'s, people from industry in the local area, 28 were M.D.'s, and 6 were senior medical students. The course is elective for the senior medical students. It carries 3 semester hours credit, and takes 50 hours of which roughly 25 are lectures and 25 are devoted to experiments.

In the lecture series, we spend the first part of the course on fundamentals at a fairly elementary level, teach nuclear and atomic physics, with a little bit about nuclear structure and instability, radioactive isotopes, and the fundamentals of radioactive decay. We have a little analog computer and we are able to use it to demonstrate the decay system.

We go into radiation dosimetry and instrumentation with a very moderate amount of electronics, not enough I'm afraid. We give several lectures on biological effects of radiation. We make an attempt to talk a little bit about the direct and indirect effects of such things as target theory, the H and OH radicals induced in media, and we go through the radiation syndrome. We touch on the effects of radiating the embryo. We try to give a good general picture but we do stress the hazards of radiation.

Actually, we have been very fortunate. We have had Dr. Morgan in 3 of the 4 years as a lecturer. In 1-1/2 hours, he gave us literature on maximum permissible levels of internal and external exposure, the latest recommendations from the National Council on Radiation, and other pertinent facts.

We have a group of lecturers whom we invite to address our own medical faculty. For example, Dr. Dingledine gives us a very excellent lecture on the use of iodine-131, diagnostically and therapeutically, and also gives the students a pretty good going over on this subject. We have a biochemist in our biophysics department who talks to them about the uses of radioisotopes in biochemistry and some of the research principles. We have visiting lecturers on cobalt-60, the uses of the Schilling test, the polycythemia vera, polonium-32, and so forth. If we were really teaching a course in basic physics, we would leave medical practice to the preceptor course which I think should be taught in the medical school itself. But at the present time, it isn't.

The laboratory sessions are rather straightforward. We have the initial laboratory session devoted to the rudiments of health physics, pocket dosimeter, and film badges. We make the students wear film badges all through the experiments just as a matter of practice in good health physics precepts and concepts. We use a one millicurie cobalt source, asking the students to do an inverse square loss and shield in experiments. We have them calibrate their counting rate needle and pocket scopes.

We then go into other experiments, using a few of the radioisotopes. We have a greenhouse laboratory where plants are raised in a $2C^{14}$ atmosphere. We carry out experiments here in some detail. We end with 2 lab sessions on how to calibrate a 1 mev X-ray machine.

This course isn't required. This is my idea of the bare rudiments of what a medical student should know before he gets out of medical school.

Last year, as I said, we had rather good success and I was quite happy to have six senior medical students. How did we get them? Well, I'll be very frank with you. We proselyted them a little bit. We got to six of the best students in the senior class.

At our school, the radiology department has training for the residents in radiology, but this kind of teaching is not given in the radiology department of the medical college at the present time.

My background is experimental nuclear physics; I'm not an M.D. I've been in the medical environment for 12 years and since then, we have founded a department of biophysics. The name of the department has not been changed to Biophysics and Biometry. Our faculty now includes myself, as chairman of the department; a Ph.D. statistician, head of the biometry effort; a biochemist, who is primarily an entymologist; a physical chemist; and a cellular physiologist.

In the course on radioisotopes, we use the full facilities of the department. For example, the statistician gives two lectures on accounting techniques in radioisotopes, from the standpoint of the process of distribution.

There are other places in the medical curriculum of the Medical College of Virginia that give bits of this kind of training. For example, for the first time this year, the chief in the department of pathology, Dr. George Margolis, who is a new staff member, has asked me to give some joint lectures with him. I have had the opportunity of lecturing to the sophomore medical students on the effects of ionizing radiation at the cellular level. I talked to them for an hour and I was rather gratified personally with the questions asked.

Certainly there are many places throughout the medical curriculum where this integration could be accomplished.

I don't believe you can name a medical school that isn't doing something about its curriculum. We are no exception. I am the only non-medical member of our committee for this purpose. The dean selected me to make the sort of comments I am making here today -- the comments of a physicist or perhaps a biophysicist.

In my service on this committee for 2 years, I feel an obligation to do everything I can do to get radiological health training into our medical curriculum. I recommend, as well, more biometry and more molecular genetics. These are the three things very much needed in our curriculum. My colleagues are inclined to agree with me, I believe.

The radiology department is perhaps the place where most of this teaching should be done, and perhaps it will be. We are in the throes of many changes. Among other things, at the present time we are looking for a new chief of radiology.

We have a very small and modest graduate program leading to a Ph.D. in biophysics and biometry with seven students at this time, four of whom are Ph.D. candidates. Of these four, two are public health officers and three are AEC fellowship program graduates, one from the University of Washington, one from Rochester, and one from Vanderbilt.

Their programs have been somewhat different. One that was set up the other day for a public health officer who is coming to join us on September 1st, can be outlined. He has a master's degree in physics; but he has not had very much chemistry. We believe strongly that a good background in chemistry is very necessary. We like our Ph.D. candidates to have organic chemistry, physical chemistry, a course in biochemistry, and a course in medical physiology.

It has come as a surprise to me that a student with a master's degree in physics from a good university cannot zoom through medical physiology. They have a hard time. We require a B, and this is not easy.

Of these four graduate students, three have elected to do a radiobiology thesis. One is in the realm of radiation chemistry at the molecular level. Another one is studying lens proteins in rabbits after irradiation, pursuing radiation cataracts in aging and senescence and the connection, if any, between radiation and aging. The third is working on complexes and coacervates which somewhat correspond to what goes on in the cytoplasm.

All of these boys have had a tutorial course with me in radiobiology, which means nothing more than that we have sat down together and gone through the modern literature up to the present moment.

We are trying to introduce in the biophysics department this year, a course which we are calling "Introductory biophysics." This is also on the graduate level. The requirements include biochemistry and advanced calculus, but we are thinking of giving a much watered-down version of this course in the medical curriculum, as a possible introductory course to first year medical students.

In this course, we would like to begin by talking a little bit about the origin of the universe and cosmos. We would like to discuss modern theories of the origin of the elements, which is as good a way as any to introduce nuclear structure and stability. We would like to come up the stage to the first beginnings of life and talk about organization, the period of evolution, the second law of thermodynamics, up to the cellular level, to the organic level, to the whole body level, and then try to place Man in his physical environment. In the course of this teaching, we would hope to have taught some nuclear physics and radiation physics, some biochemistry, physiology, cybernetics, logistics, or a little bit of everything, in a panorama-type course.

Don't think that this man is expected to know too much. We hope only to introduce him to a panorama of the life process. From here he may be able to choose where he would like to go.

I am trying to persuade the dean of our medical school to permit our department to give a 30-hour course to the freshmen medical students along these lines. We will, of course, require the help of the other departments.

These are some of our tentative plans and an analysis of the manner in which the staff of the department of biophysics is attempting to get radiological health concepts into the medical curriculum and is trying to influence the thinking along these lines.

Dr. Titus C. Evans: The principles of radiation protection are similar for those going into research and into teaching. However, the approach needs to be a little different. We are dealing with people who are very well-trained, very intelligent, who are curious, and who don't like to be policed. In contrast to places where it seems best to point out that everything is policed and well-controlled, when dealing with graduate students and university students, in general, we like to keep the police aspect hidden.

This we try to do by working with people, letting them know we are trying to help them get their research done, that we are not trying to retard them. We attempt to get them interested in the principles of radiation protection. We encourage them to understand and to feel that this is a technique that is just as necessary as mathematics or any of the other tools that a man needs in order to do research, and in order to be a good teacher.

Several years ago, some of us worked up a paper on radiation protection measures in a university which was published in Radiology, Volume 65, pages 875 to 882, 1955.

I would like to discuss our approach at the College of Medicine of the University of Iowa (see p. 132). Unquestionably, we are a part of the university, on the same campus with the physics department, the chemistry department, engineering school, and so on.

The requirements and needs may be a little different for a medical college which is separate from the other colleges of the university. But we have the central area of concern, you might say.

We call it a radiation research laboratory. This laboratory doesn't belong to any department. Several of the members of the laboratory staff are associated with the department of radiology, but no one recognizes us as being either preclinical, or clinical, or even medical. Our dealings with people in physics and in chemistry are almost as close as with people in radiology, in internal medicine, and so on. And they have the feeling that we are concerned about their radiation problems, but that we are not necessarily policing them.

On the other hand, we have very strict control from the very beginning. A research man, and even the purchasing department, needs some control. It is a temptation to save money by buying curies or millicuries of something all at once, rather than buying a few microcuries as you need it. The cost of storage and disposal far outweigh the initial saving in many instances. No one can purchase radioactive material without calling it to our attention. University regulations require that such purchases must be processed through the university isotopes committee, or its subcommittee for human uses. In this way, we are able to control applications for license and each purchase has to conform with the license as it was approved, both locally and through the AEC.

Our relationship with the radiology department is close, as some of our people are helping in the dosimetry and radiation protection procedures and the like. And of course we help in the training of the residents. I believe that our main responsibility here is to train, to encourage, and help the radiologist in being responsible for clinical radiological protection in the hospitals.

Anyone using an X-ray machine who has any questions or feels unhappy or uncertain should be able to turn to the radiologist and the diagnostic man as well as the therapy man. The radiologist has a basic understanding of radiation protection and he is the one with whom a nonmedical man should be able to work in education and in training to accept responsibility for protection in the hospital.

We maintain liaison with the department of health in the College of Medicine. They have representation on the general university radiation committee and on the committee for human uses. This department reports annually to the university president on health conditions on the campus and radiological health is an aspect that is included. And then we are fortunate that a branch of the State department of health, the State Hygienic Laboratory, is located in the College of Medicine building. We work with other educational institutions in the State to supply the Governor and the State department of health with an advisory committee on radiation. We are studying other State codes and ultimately we will make suggestions to the Governor through the board of health regarding a radiation code for the State of Iowa.

Each department in the liberal arts college and the engineering college has one person assigned to radiation protection and our film badge and consultant service works through this departmental representative. We inform this representative that we have extra instruments in case of emergency and we are called if there is any concern about a possible radiation hazard.

Most of our teaching is done at the graduate level. This brings up one point about the medical curriculum. Medical students are on a trimester basis; the graduate college is on a semester basis. For this reason, we haven't considered a separate course in radiobiology for medical students, even medical students in their senior year. They just couldn't work it in. But we do get them in the summer in various ways. They work in the laboratories, they come around and talk, and some of them have summer fellowships. So we do encourage a few medical students who are already interested. But we don't have the opportunity to teach the medical students generally.

In the graduate school, we have an introductory course in radiobiology but we don't separate isotopes from radiation effects. We don't like to train anyone to use radioisotopes without training them to understand radiobiology. We believe these two should be learned together. We start with biological effects of radiation and then consider radioisotopes. Finally, we tie the two together with the hazard aspects of radioisotopes, how to use them safely, how to calculate dosage, and so on.

In advanced courses, we cover parts of the same material as the initial course but instead of being didactic, we are now inquisitive; we go into the literature and we discuss each point in more detail. We give the student a chance to develop a particular interest. If he is a chemist, we give him a problem in chemistry. If he is a bacteriologist, his laboratory work is a little different from the others who are not.

In addition, we have advanced courses in radiological physics, health physics, and the biomedical application of isotopes. We have seminars, special topics, and research projects.

Radiology residents spend a month with us sometime during their residency training, during which time we give them individual instruction. We work with them on all of the laboratory and all of the isotope techniques. Since we act as the university's radioisotope laboratory, we may be working with a hematologist one day and we may be working with a radiologist on a therapy problem the next day, so the residents become familiar with all aspects of isotope work. We have recently completed our plans for a degree program with radiation biology as the major field of study.

The burden of radiation protection in the hospital is assigned primarily to residents in radiology. They are advised by us and by the senior radiology staff, but they maintain the contact with nurses and patients. We do the monitoring, working with the radiology residents on these projects. The radiology residents come back after they have been away a while, and we expect them to spend a few weeks with us as a refresher before taking their Board examinations.

In teaching medical students, our basic problem is that the graduate college is on one plan, the medical college is on another. But we do most of our teaching in the medical college through the department of public health and preventive medicine, during the junior year. I lecture to the whole group on the historical development of radiation and its applications. The laboratory part of the course consists of tours to various places that represent health problems. The class is broken up into groups of 15 or 20 and we go through two cycles. In the first cycle, the group visits the laboratory for 3 hours. We introduce them to external radiation hazards. We show them the X-ray machine; we show them roughly how we calibrate it. We explain the use of concrete and lead and leaded glass. We show the students pocket chambers and film badges, and we explain them. We demonstrate shielding, remote control devices, what we use for protection against external hazards.

Later there is a second tour. This time we stress potential internal hazards. This gives us time to describe the use of radioisotopes in diagnosis and in therapy, and also give the students some basis for understanding how one can transfer knowledge about external hazards to those from internal emitters.

The subject matter of this introductory course starts with radiation physics, the interaction of radiation and matter, periods of biologic action, chemical effects, cellular effects, genetics, tissue effects, whole body syndromes, the acute, subacute, and chronic reactions, the effect of protraction, and the effects of fractionation. Then we take up nuclear physics, detection, measuring devices; we describe the various techniques used in radioisotope work, in vitro counting, scanning, labeling compounds, metabolism, and use of tracers. We study thyroid metabolism and we go through the biochemical, the physiological, and the clinical aspects of the thyroid. Then we take up hematological aspects; Fe-59 clearance and its reappearance in red cells; chromium-51 in red cell life-span studies; cobalt-60 labeled vitamin B-12; and iodinated human serum albumin. We have so many clinical problems under study that we usually have an internist or a radiologist around when we are doing laboratory work so that if anyone has a special interest, we can give them detailed information about the usefulness and limitations of radioisotopes in this instance.

We end with radiation protection regulations, covering the historical development of protection committees and regulations. We discuss techniques and we review the information learned about radiation effects, correlating this with what is known about the radiation hazards of internal emitters.

We try to cover the basic principles without too much time being spent on practical training, but usually we find that we arouse enough interest in them so that the students are doing a problem with us eventually.

In time, the present facilities may not be satisfactory. The problems seem to increase at a rate equal to that of the answers.

However, at the present time, the concept of a central research laboratory staff with a special concern about radiation hazards, and special curiosity about radiation effects, seems to be a way of meeting the radiation hazard problem to the satisfaction of those who are (or will be) researchers or teachers.

Dr. James G. Kereiakes: There are three major ways in which large populations can receive increased radiation. These include medical exposure, industrial exposure, and exposure from weapons.

In conducting a useful program in radiation health, it is essential to balance the contribution of each of these against the hazards. If a wave of public hysteria which can be easily generated is set in motion, the deleterious effects of such publicity easily can become greater than the danger from the radiation.

Dr. Russell Morgan recently expressed a thought concerning radiation protection which is, indeed, intriguing. He said that standards of protection are, to some degree, in accordance with what we believe we can afford. Thus we find now, with relatively inexpensive improvements, that we can work safely at levels of 5 rem per year or less, whereas 20 years ago we permitted doses up to 50 rem per year.

No single university department of radiology can hope at present to develop comprehensive programs. Rather, each institution should concentrate on such capabilities as reflect the interest of the several principal investigators working in that setting. Thus, by a combination of facilities available for basic scientific training in the graduate schools of arts and sciences and by work in the specialized laboratories, individuals can be trained properly in the pertinent disciplines.

A strong academic background coupled with a practical understanding of applying this program to particular problems in radiological health is essential. Also there is a distinct advantage in having trainees study in more than one institution if they are to be trained at more than a technical level. As all of you well know, there are many different types of background among teachers in this relatively new field of radiological health and many different viewpoints.

The field of radiological health reminds me quite a bit of the present similar situation of its sister field, radiation biology. There are as yet no professional radiological health personnel nor professional radiobiologists. We are either physicists, chemists, engineers, or persons in medicine and allied sciences using our talents in a relatively new and yet extremely important area. Yet our different viewpoints on the subject of radiological health are essential for its future growth. Rigidity in thinking about radiation and health should be avoided.

Our interest at the University of Cincinnati College of Medicine at present is in the development of four categories of trainees (see p. 104). First is the physician who has completed his residency and is to receive special training of 1 or more years in radiation techniques as applied to his special field of interest, but not necessarily limited to radiologists. At present one of these positions is being filled by a pediatrician.

Their training should include a research problem for which the trainee is responsible. In addition, he works with physicians in other fields on special phases of current problems in the department so as to develop experience in research team methods.

The second category is the resident in radiology. The radiologist, whether diagnostic or therapeutic, can exercise considerable influence over the safe use of radiation, both in medical practice, and in the public health aspect. In the past, a radiologist has been trained almost exclusively in diagnosis, in therapy, and in the pertinent radiation physics. In addition, we emphasize training in radiobiology, both in seminar lectures and laboratory work. The resident receives detailed training in radiation surveys and calibrations of his equipment. He is given training in metabolic pathways of radionuclides as well as training in practical diagnosis and therapy, using these radioactive substances. Some material is presented in radiation epidemiology and in industrial problems. Statistical techniques are emphasized.

All trainees also participate in the programs just mentioned above.

A third category is the graduate student in physics. Each year, one to three graduate students in physics or biophysics are accepted for training in our laboratories. Training is given in radiation techniques, such as radiation standardization and survey procedures, personnel monitoring, and so forth. They spend time in diagnosis and therapy and in the use of radioisotopes. They become well acquainted with teletherapy and radium dose calculations, radioisotope diagnostic and therapeutic procedures, and proper radiation counting procedures for patients receiving radioactive material. Often their thesis will reflect work done in this program. I say "will" because at present this program is just being initiated.

The fourth and final category of trainee is for the physician who plans to enter administrative phases of radiation health. Its purpose is to acquaint them with medical techniques currently in use. The emphasis in this program will be on participation by the trainee, rather than on observation.

The course work and laboratory work offered to trainees by the radiology department and by the radioisotope laboratory include the following: Mathematics of radiation physics; radiation physics; radiological sciences laboratory, including experiments with radiologic instrumentation and with radioisotopes; radiation safety lectures and laboratory; radiation dosage planning; and clinical uses of radioisotopes.

Special courses for the trainees include the following: Radiobiology 1, which gives the interaction of radiation with matter; radiation chemistry; hematological, physiological, pathological, and biochemical effects of ionizing radiation; genetic effects; radiation carcinogenesis.

This is followed by a radiobiology 2 course, giving the models of action of ionizing radiation; relative biological effectiveness of different types of radiation; chemical, physical, and physiological protection against ionizing radiation; and a series of experiments, primarily with mice and rats, demonstrating lethality dose response relationships; dosimetric techniques; modes of radiation death; RBE determinations for different types of radiation; the effect of protective agents; and isotope distribution.

A third special course is a statistics course conducted by a visiting consultant for a 1-week period at regular intervals. These are seminars in the use of statistics as applied to clinical research, with special emphasis on the design of the studies. He cooperates actively with the trainees in their individual problems. This summer we had the fortunate experience of having Dr. H. C. Batson of the University of Illinois with us.

It should be noted that we do not offer a program leading to a degree in health physics, either through the department of radiology or the department of physics. At the Institute of Industrial Health, known as the Kettering Laboratory, physicians who study industrial or public health receive training in radiation and a health physics program will be offered there this fall.

Under our present program, we do not train technicians. Lectures and demonstrations are given to medical students and nurses through courses given in other departments. Opportunities are available for participation by medical students in radiation research problems and one to three of these work in the laboratories each year.

Our primary interest is in the development of individuals in physics, or biophysics, in medicine or the allied sciences, who will be able to conduct research in the future on the effects of radiation on normal and diseased tissue. Therefore, in our opinion, it is important that the trainee be exposed to and actively participate in research problems. Through the course work, he obtains a basic background of knowledge and more important, through the active participation in the work and research of the department, he obtains the competence to apply this knowledge.

At the present level of the art of radiological health, we believe that this approach is essential. Each trainee is given responsibility in some aspect of an investigation, depending on his background, on his ability, and upon the length of time that he is with us. Currently, our research program includes studies in epidemiology, metabolic effects of radiation in humans, both with whole and partial body radiation exposure and with radionuclei; and various studies utilizing radionuclides for research and medical diagnostic purposes. The metabolic effects studied in humans include amino acid chromatography of urine, blood and urine creatinine and creatine, complete blood analysis, electrophoretic patterns of blood, immunoelectrophoretic studies, and others.

Not only do the trainees who are physicians and graduate students participate in these programs, but each of the residents completes a brief study in the 2 or 3 months period that he is with us.

A brief description should be given of our organization. The training program is carried on by the department of radiology and by the radioisotope laboratory. The laboratory is not formally under the supervision of any department of the medical school but is supervised by a committee representing the departments of radiology, surgery, and medicine. The actual work is administered by a director. The virtue of this approach is that it provides ready access to our specialized facilities by all departments in the medical school and permits active participation in a wide variety of research and clinical problems throughout the hospitals by our staff.

Our present staff includes one physicist Ph.D., one physicist M.S., four physicians who are radiologists, and three internists on a part-time basis, one of whom is an endocrinologist and two of whom are principally interested in hematology. There are four nurses, three technicians, and an electronic technician.

There is close liaison between our department and the biometric section of the department of preventive medicine so that proper experimental design and statistical control of research and clinical problems are constantly maintained.

The support of the National Cancer Institute, the National Institutes of Health, and the division of biology and medicine of the Atomic Energy Commission is acknowledged. The support of these agencies has been essential in the development of our program.

In our opinion, a sound radiation health program depends on the mutual participation of the universities and the Federal government. The program should be broad and particular emphasis should be placed on training in the field of medicine and its allied sciences.

Many radiology departments have added radiation physicists and radiation biologists to their staffs. They are able to offer the courses that I have listed. These courses, in addition to the courses offered by other preclinical and clinical departments of the medical school and by other divisions or departments of the medical school, should suffice as course work for radiological health training.

There may be a requirement of some special courses for specific needs, but the emphasis should be on laboratory work and on the participation of the trainee in the research work of the department.

Here, more encouragement and support is needed. As mentioned by Dr. Stannard, the division of biology and medicine of the Atomic Energy Commission has done much in the direction of supplying equipment necessary for training in nuclear technology, but funds are needed for equipment for specialized research projects.

Normally, there are at least one or more hospitals associated with a medical school and medical center, and the trainees are exposed to research work with humans. In particular, our trainees see the patient prior to treatment, observe the radiation exposure, see the patient following treatment, and have ready access to all of the results on the patient. In fact, in some cases, trainees make some of the measurements and are aware of the effects of radiation. In addition, in the use of radioisotopes, our trainees are there at the time of either the diagnosis or therapeutic dose of radioactive material. They count the patients, either by uptake or scanning techniques, and participate in many of the procedures with radioisotopes which Dr. Evans mentioned earlier today.

The important thing is that the trainees do have contact with patients and we feel that is important in any training program because inevitably, in the end, we will be interested in the effects of radiation in humans.

A rough dollar estimate of the cost of a program in radiation health training in a hospital set-up is in the neighborhood of around $50,000 a year. I'm saying this primarily from the type of training grant money concerned.

Dr. Richard H. Chamberlain, chairman: There was a comment this morning by one of the speakers, I think, who is using the radiation safety committee as an educational agent as well as a control agent in the university. This is an experience a good many of us have had. Trying to place dollar values on this is difficult because in our own institution, for instance, we have a university-wide radiation safety office, operating under the direction of a joint committee, with two full-time radiation health physicists, one technician, with another technician being added. While the budget for this office runs about $35,000 to $40,000 a year, you might well assign $5,000 or $10,000 of this to teaching value. Every time a member of the staff goes out to survey or advise, he is doing a teaching job.

He is not only protecting the university and the public, he is educating. Actually our radiation health man has given courses for the janitors and plumbers of the university in an effort to avoid either undue concern with or disdain of a pipe that is labeled with a radioactive symbol when they have to install a sink or when a trap is stopped.

Dr. William E. Elliott: This is a description of an experiment in medical education, an experiment in which we realize that we do not have optimum conditions as yet.

We started our deliberations and discussions in the fall of 1957, when it became evident that funds would be placed at the disposal of those who requested them for the purchase of equipment when teaching nuclear technology in medical sciences.

We had been following the pattern of other medical schools, carrying out experiments in the various departments as the desire and the ability to do so developed (see p. 126). In 1957, we began to coordinate our activities and we formed a committee of those involved in such teaching which we called the Committee on Teaching of Radiobiology. The chairman is Dr. Edward Doise, Sr., chairman of the department of biochemistry. We are fortunate in that the department of biology is housed in the school of medicine and we can use some of its talent. We have been promised similar assistance in the department of chemistry.

The committee consists of about nine members from seven different departments. We studied what could be done, organized our thoughts, and sought the support of the administration of the medical school.

The answer to this is verified today by the presence of Dean Colbert at this symposium.

We then applied to the AEC for funds and, while we waited for approval, began teaching freshman biochemistry the first calendar day in the new year. So we began instruction in biochemistry in January 1958, realizing we would have no equipment for the class. Rather than lose them, we pulled equipment from the research laboratories to carry on our demonstrations, we borrowed film, we borrowed whatever equipment we could, in order to indoctrinate the students in the thought that by the time they became sophomores, they would have some training.

In the spring of 1958, we were granted a total of $25,000 by the AEC which was used to purchase equipment for teaching. At the same time, we presented our thoughts on the matter to the Rockefeller Foundation and were awarded $62,000 for a period of 5 years. In 1959, we received from AEC an additional $22,000.

The funds used totaled then some $47,000 for purchase of equipment and some $62,000 over a period of 5 years for instruction. With the Rockefeller grant, we have been able to refurbish student laboratories in biochemistry and anatomy. We have been able to build a better, larger darkroom for radioautography and supply stipends for two graduate assistants, available for all departments involved in the teaching of radiobiology. And we have additional funds for supplies, books for the library, and things of this sort.

Instruments purchased included approximately a dozen units for geiger counting, about 11 units for scintillation counting, approximately 8 or 9 monitors operated by 110 volts, and 8 or 9 battery models. Additional equipment included auxiliary equipment that would normally be used.

This equipment is used in laboratories for teaching of radiobiology. It is not used in research. The instruments are mobile. We put them on carts where necessary and move them about the building to the laboratories where they are needed. When they are not used in instruction, they are stored.

Our normal freshman class numbers about 125 students. Our freshman class in biochemistry, where instruction in radiobiology begins, includes graduate students who seek training in biochemistry, and medical technicians. The size of the freshman class in biochemistry is larger than the medical class involved.

We give a total of about 44 hours of lecture material, and about 100 hours of laboratory instruction.

Dr. George E. Thoma: In our undergraduate radiobiology program, our section on nuclear medicine had the primary responsibility for at least coordinating the clinical program in the junior and senior year (see p. 126). This is accomplished in a series of lectures beginning in the junior year. We use a technique of lecturing to all of the students in the junior and senior year. These so-called combined clinics are held on Friday in about a 2-hour session.

The lecture is integrated with other lectures in clinical medicine when these techniques were applicable. For instance, in the series on thyroid, there are 4 hours devoted to discussions of physiology of the thyroid, pathophysiology of the thyroid, and clinical aspects. It is during this series that we give our two lectures on the techniques and principles of thyroidal uptake of iodine, localization procedures, and therapy.

The lectures called the combined clinics are repeated every 2 years to assure that all junior and senior year students attend.

The lectures given in public health are distinct and are not a part of the combined clinics. We lecture in epidemiology, radiation injury, population effects, and protection as it relates to the general public, not as an occupational hazard.

In the junior year, we have laboratory sessions. The class is divided into very small groups and there is a short 30-minute lecture preceding each laboratory period.

We initiate a series of laboratory experiments by doing the red cell survival study in the first laboratory period. At each subsequent laboratory period, the student receives another sample brought from a patient on the ward, carrying out the red cell survival study over the period of the five laboratory periods.

In other laboratory sessions, the student has an opportunity closely to observe the procedures.

We have a section of nuclear medicine in the Department of Internal Medicine. This is in the outline of the nuclear medicine programs.

We distinguish postgraduate education from postdoctoral. This is, shall we say, the non-academic type of postgraduate training. A course in the medical aspects of radiological health is being given this summer for 8 weeks in St. Louis and 1 week in Oak Ridge. We have 13 students in the course, 12 of whom are Public Health Service officers. This is a pilot study. We are more anxious, really, to see the critiques than the final examination, so we can be guided for future presentations.

In addition, we give a course in nuclear medicine and clinical practice as a part of the postgraduate medical education program of the St. Louis Medical Society. This is variable in time, but we give about 16 hours to this--2 hours, 2 nights a week, for 8 weeks. This is very definitely clinical, but we have two and probably three lectures on radiation protection and radiation effects for the clinicians. The men who take this course from the medical society are already in practice--men who simply want a refresher or to pick up some new techniques.

We also have postdoctoral research training in nuclear medicine. It is my private opinion, at least, that radiological health specialists fall into the category of the administrative people, and it is not likely they will ever be considered as a distinct entity in clinical medicine. But we feel that there is a definite place for physicians with a sound clinical foundation in the field of radiological health and we have a program to supply this type of training.

This is a postdoctoral training program. We have two Fellows in the program now, both of whom have completed their 3-year medical residencies and are going on for either 1 or 2 years training at this level in nuclear medicine, which will include most of the aspects of radiological health, certainly those with which physicians must be familiar.

We are attempting to satisfy as many of the requirements for training in radiological health as we can, but we do believe strongly that there is a place for at least a limited number of physicians who are well grounded clinically in the radiological health programs.

The Review

Dr. J. D. Porterfield: It is always pleasant to appear before an audience comprised largely of university people. That pleasure is enhanced when the meeting is at the site of one of the world-recognized centers of learning.

Perhaps this is an atavistic phenomenon arising from hope that the wisdom of the great men who have studied and taught at Princeton in the past, or whose work has been preserved in the library here, will rub off on us.

Certainly we need all the wisdom of the past, and much of that which is to come, in order to meet the health problems that are emerging from our rapidly changing environment. Explosive and highly concentrated population increases; massive industrial growth; air and water pollution; new and untested chemicals in our foods and medicines; the all-pervading threat of ionizing radiation--these are grave questions which demand careful study. They demand multifaceted yet smoothly coordinated plans. Above all, they demand deliberate yet vigorous action.

This meeting has been concerned primarily with the especially trained manpower this nation will need if we are to cope with the health problems of ionizing radiation. However, it might be useful if we review briefly the total problem of environmental health. Therefore, I shall summarize Public Health Service programs and plans in environmental health generally, as well as in radiological health.

Western man has achieved relatively good control of a primary hazard of the environment--biological agents of disease. This has been both a result of, and an important contributing factor to rapid advances in science and technology which have affected other aspects of the environment.

Since the turn of the century, our U. S. population has more than doubled, and most of the increase has taken place in our cities. To feed, clothe, transport, educate, and safeguard the health and safety of this population at a constantly increasing level has required a constantly increasing degree of industrialization. It has required vastly expanded manipulation and use of our basic resources--air, water, minerals and food supplies. Thousands of new chemicals have been introduced into the environment by way of drugs, foods, clothes, and cosmetics, and into the air we breathe and the water we drink. Our use of old energy sources has increased and a new source, ionizing radiation, has been added, producing a whole new spectrum of hazards to all living matter.

As pointed out by the Surgeon General in recent testimony before Congress, the health problems posed by these developments differ in three significant ways from health problems as we have known them in the past.

The first of these is the nature of the biological assault. The health professions and the public are accustomed to the communicable disease pattern. The disease strikes; a period of illness is generally followed by recovery and often by residual immunity; and there are no genetic consequences to concern us. The time span between exposure and onset is relatively short; cause and effect relationships are relatively easy to establish, leading directly to preventive measures upon which much of public health and individual medical practice have been developed.

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By contrast, the biological effects of chemicals in our environment, or of low-level radiations, are cumulative over long periods of time. The effects that are our greatest concern often are far off in the future of the individual or of the species. Predicting those effects and relating them to cause is extremely difficult. The hazard to the individual is related to the cumulative total of radiations or chemical toxicants received continuously or intermittently throughout his life, regardless of their sources. The genetic hazard to the species from low-level radiation must be extrapolated far into the future and thus is even more difficult to assess.

The second of these significant differences involves a broadening of our definition of the "health professions." The pattern we have evolved has required that we think of health manpower in terms of physicians, dentists, nurses, sanitary engineers, and a variety of supporting technicians. Recent scientific advances have added biologists, physicists, and chemists as indispensable allies. But the environmental challenges facing us today also demand the knowledge and methods of the physical scientists on the one hand, and behavioral scientists on the other, and a bewildering array of specialties within the standard disciplines of each.

The third difference between the new environmental challenges and those of the more traditional health problems lies in the complexity of the political, social, and administrative structure within which solutions must be found and applied. Traditionally, the responsibility for health protection has rested with the level of government closest to the people. The community, aided by the State, has been the first line of defense.

But the concentrations of people in metropolitan centers has greatly complicated the structure of local government and its relation to the State. Many of our metropolitan areas already sprawl across State boundaries, and more will do so in the future. Moreover, each of these metropolitan centers is in itself a constellation of governmental and quasi-governmental agencies.

Our supplies of air, of surface and underground waters, and our highly developed system for the marketing of food supplies at distances remote from their origin do not recognize municipal and State, and sometimes not even national, boundaries. Yet these vectors of the newer hazards are being dealt with fragmentarily by scores of officials and groups. It is increasingly apparent that if we are to cope effectively with these new problems, our concept and organization of public health must be adapted to these new social and political patterns.

Finally, and of greatest significance, our approach to nonbiological environmental health problems differs from classical public health goals in that it must employ a technique of containment rather than eradication. In a heavily concentrated, highly industrialized and competitive society, a certain amount of deterioration of the environment is inevitable.

We must find a balance which permits maximum utilization of modern technology at minimum hazard. This involves decisions of public policy, with economic and social ramifications which extend far beyond the responsibility and field of competence of the health professions. However, it is our duty to furnish specific kinds of evidence to all those who determine public policy, so that benefits and hazards may be weighed in the balance with the other factors involved.

About two years ago it became clear that the Public Health Service and its advisory groups should conduct careful studies of the totality of these problems as well as of the various components. Several panels of expert consultants and of committees from within our own organization have examined various aspects of these questions and have submitted reports and recommendations as to what should be done. The gist of the recommendations, in the words of one advisory group, was that "to provide the necessary leadership in the effective expansion of the total national effort the Public Health Service should devote greater resources to research and education in this field (of environmental health)."

Another group made, as its principal general recommendation, that a major organizational unit should be established within the Service to direct a unified, overall approach to the problems of the nonbiological environmental hazards.

However, even cursory knowledge of public health indicates that virtually every aspect of it has an environmental component; thus almost every established program in the Public Health Service has, over the years, become involved, in greater or lesser degree, with the environment. It became clear that to establish a major organizational unit to provide a unified, expanded approach to environmental health would require a total reorganization of the Service.

Thus, the Surgeon General several months ago directed a special task force to restudy the mission and organization of the Service as a whole. The recommendations of that group, which both the Surgeon General and the Secretary of Health, Education, and Welfare have accepted, included the formation of a Bureau of Environmental Health, with the following clearly defined characteristics:

1. It must have a staff of highly qualified persons representing the many disciplines involved in this field and capable of providing guidance to the total environmental health efforts in the United States.
2. It must provide for the integration of the biomedical and engineering operating groups in their day-to-day activities, and for the closest possible relationship between the research and operational components of the environmental health effort.
3. In addition to a strong and closely coordinated intramural research center or centers, it must have an extensive extramural program making use of the laboratories of universities, industrial organizations, and official and nonofficial agencies throughout the country. The extramural program should, with the assistance of Federal grants, encompass the strengthening of existing laboratories and the development of new ones by universities or other organizations, to perform highly specialized research and serve as centers for expert consultation and teaching programs.
4. All of the working mechanisms of the Public Health Service—direct operations including research, training, and technical assistance; grants and contracts for research, demonstrations, and training—must be available for all of the environmental health activities.

Since it is germane to our discussions here, let me emphasize that this proposal envisions research centers in various parts of the nation whose function it will be to provide technical assistance, conduct monitoring programs, do research on special problems, and act as training centers. These research centers should be related as closely as possible to university and other research facilities.

Recommendations have been made to the Congress for legislation which would authorize the full reorganization, and the creation of the Bureau of Environmental Health. It is hoped that such authorization will be granted in the near future.

Meanwhile, over the past two or three years a number of steps have been taken which, within the framework of our present organization and legal authority, lead in the same general direction of giving more Public Health Service emphasis to environmental health problems. Foremost among these was the creation in July 1958, of the Division of Radiological Health.

This action was followed closely by the submission of a report prepared by a National Advisory Committee on Radiation headed by Dr. Russell H. Morgan, Professor of Radiology at the Johns Hopkins University Medical School. Very heavy emphasis was given in that report to the need for rapid and massive expansion of the nation's manpower trained in the various medical, biological, chemical, physical and engineering aspects of research, control, and administration in radiological health.

A hint at the health implications of the nuclear era as presented in the Committee report deserves summarizing here.

> "A comprehensive program of radiation control appears particularly important. . .in view of the increasing breadth of human activity wherein ionizing radiation is a significant health hazard. X-ray machines are now used extensively in industry as well as in the health professions. Radioisotopes are finding application in a rapidly increasing number of industrial plants, university laboratories, hospitals and agricultural research centers. And nuclear reactors are being planned and constructed at an accelerating pace. Few areas of human activity remain where sources of ionizing radiation do not find some practical application."

In substantiation of this statement the report then cited data which showed:

> Between 1925 and 1955, the estimated annual wholebody X-ray dose received by the average individual in this country increased 900 percent--from 15 millirems in 1925 to 135 millirems in 1955.
>
> Between 1952 and 1958, the number of medical users of radioisotopes in the U.S. increased more than 400 percent--from 445 to 1,935.

The predicted growth of U.S. nuclear power capacity from 1965 through 1995 will result in an increase, in the accumulated volume of high and intermediate level wastes from 1,500,000 gallons to approximately 2 billion gallons.

To cope with present and predictable health hazards of these magnitudes obviously requires adequate regulatory powers applicable to the particular situation in every affected area of the nation. It requires that surveillance be maintained to assess the current levels of exposure from various radiation sources in local areas, for larger geographic regions, and for the nation as a whole. There must be central collection, analysis, and interpretation of radiation data. Research, both fundamental and applied, must be conducted on the biological effects of low-level radiation, with special emphasis on epidemiological study and on methodologies for prevention or abatement of unnecessary exposure.

Finally, radiation protection activities must be coordinated with other national, State, and local health programs dealing with a variety of related problems, and extremely close working relationships must be established with the medical and other professional groups having a primary interest in the problem at hand.

These prerequisites for a national radiological health effort form the blueprint of the rapidly growing program of the new Division, conforming in all important particulars with the time-tested triad of research, technical assistance to the States, and training. Our Division of Radiological Health has made good progress in all aspects of its mission, the details of which have been covered in previous discussions here.

In summary, I want to emphasize that we in the health profession have a responsibility of very grave importance to the nation to assess accurately the public health problems associated with the present existence and the anticipated future growth of man-made ionizing radiations. This responsibility is but one of many which face us as a result of continuing scientific advances, industrial growth, and population increases.

Our objective should be to anticipate the future course of the radiological health problem, and others in this family of environmental hazards, and begin now, before they attain unmanageable dimensions, to establish the manpower goals necessary to their solution. Whether we can do this lies principally in our ability to devise programs which coordinate all facets of a particular problem within the framework of a much larger, but related, set of problems. Such manpower goals would include competencies to estimate the magnitude of a given health-impairment factor in the environment, to evaluate the mechanism and extent of body damage, and to devise and apply effective preventive or control measures. They would enlist the research capabilities of many interrelated technical disciplines and institutions, and, at the same time, serve in a training capacity to meet the needs for specialized professional manpower.

Currently, chronic illness has supplanted communicable disease as the primary threat to national health. In our efforts against chronic disease, we have come to appreciate that a broadened approach to human biology, genetics, biochemistry, pharmacology, and other sciences is necessary to a thorough understanding of the mechanisms of chronic malfunctions. Simultaneously, the various environmental contaminants have become recognized as potentially significant factors in the increase of chronic disease. Again, a thorough understanding of the biological damage and modes of action of chemotoxins and radioactive materials is dependent on a broadened understanding of the physiological sciences.

In essence, we might say that the transition from infectious disease to our present-day problem of chronic disease and potential genetic damage has caused a sharpening of focus from bacterial down to molecular magnitudes, insofar as an understanding of cause-and-effect relationships are concerned.

The discussions we have had here of the new health challenges facing our nation point up the need for a broad approach into many fields of science. We are concerned with the shortages in all disciplines and the difficulties in competing with other important areas of scientific endeavor which are better established. To enable environmental public health programs to get under way within a reasonable time, we in the Public Health Service hope to focus much of our interests and resources at university centers in order to stimulate recruitment and training of personnel, as well as to amplify research.

To implement this plan will require legislative authority, and financial support.

We recognize that, should this program come into being, it must be planned in the best interests of all concerned. With regard to the university interests, for example, there should be a rekindling of true research potential and less emphasis on the purely developmental type of research and training. And in terms of public health interests, we must attempt to define a broad action program toward which student interest can be focused, and in which stable and professionally rewarding positions can be created.

Dr. Richard H. Chamberlain: The educators in medicine participating in this symposium were somewhat dismayed by the complexity of the problem that confronts them. There were so many complexities and ramifications that we have limited our thoughts to some of the key areas.

We found this true not only in personnel, both as subjects of education and as educators, but also in the variations in the extent and scope of education that would be wise for each of a variety of different people.

Running as a thread through practically all of our discussions was the desire of the medical profession to be free of undue restriction and awareness of the moral responsibilities related to this freedom. This is a kind of a two-way stretch, the need being closely related to what doctors will undertake as their responsibility.

We made some lists of the type of people involved in medical school education in radiological health.

We considered radiological physicists—the group suitable for American Board of Radiology certification in radiological physics.

Closely allied to them but in a parallel and somewhat divergent line are the radiation health specialists, a key group to the educators whose primary interest is in this interscience fusion of the biological and physical regimes.

Another huge and diverse group represents all doctors. There was emphasis placed on the undergraduate M.D., the regular doctor in medical school, but some references were made to graduate training and to the training of doctors now in practice.

There was discussion of the great variety in the intensity of training needed by the different specialties, and again, a very partial list would include not only radiologists, who are obvious, but gynecologists, orthopedists, pediatricians, dermatologists, and the rest, with a particular mention of the isotope specialist.

We don't quite know where to put the preclinical people—the radiobiologist, biophysicist, and geneticist.

We considered the obligations of the medical school in teaching and education to other sciences outside of the medical or the health family--the physicists, chemists, and engineers. And we considered another segment of this family—dealing primarily with radiation protection or with radiation as a tool.

We centered our attention on three groups: First, the radiological physicists and radiation health specialists; second, the undergraduate M.D.'s; and third, other specialists. It was our hope that the others would more or less fall in line if we could arrive at some unanimity of opinion on these three major groupings.

We discussed course standards—a high professional level versus the trade school approach. This is difficult because one man's high professional standard is another man's trade school standard. Of course, we are all interested in relatively high basic standard levels.

We discussed emphasis—the balance between the theoretical versus the practical, between not allowing the hazardous or the potentially hazardous aspect of radiation to outweigh equal educational emphasis on the benefits to be derived because this leads to misplacement of emphasis and to an unbalanced educational program.

We discussed the didactic versus the apprentice approach. There was good agreement that both types of education are needed. In educational circles, there are people who believe that one or the other should be used exclusively. Our group agreed to a large degree that both types are necessary. This has a strong bearing on requirements in facilities, space, and money.

We discussed who should teach. There was some difference of opinion about this, some believing that teachers should be drawn from their own field, that physicists should teach physics and that biologically minded people should teach biological subjects. Others believed that the most happy union is achieved when the physicist can learn to speak in biological language and the biologist can illuminate his remarks with illustrations drawn from the physical world.

We discussed who should be educated and with what priorities. The radiological physicists and radiological health people probably should have number one priority, with the M.D., the undergraduates, and the specialists second. However, in staffing and space to teach, there seemed to be some feeling that although the radiological physicists and radiological health specialists should have number one priority, when their needs for space and personnel were satisfied, that radiobiologists should have second priority.

We discussed the present effort. Many of us were both pleased and amazed at the intensive programs now in progress in certain institutions. Amazingly elaborate programs have been put into effect and appear to be succeeding in such places as Rochester and St. Louis.

All of the courses delineated seemed to include atomic and nuclear physics with mathematics included; radiation measurements in dosimetry; radiobiology, strongly included with genetics and radiopathology; physiological mechanisms or metabolic pathways; epidemiology; and biostatistics. Practical experience always was included both in X-rays and isotopes.

There were several comments made concerning institutes such as the one at Rochester which was devised primarily for preparing people for the Atomic Energy Commission program. It was suggested that perhaps these programs could be more effective by adding practical experience in uses of radiation other than the ones primarily Atomic Energy Commission-directed, in the field which might be called protection itself. This balanced viewpoint is something that is difficult to teach but undoubtedly can be illuminated for the student's mind.

There are, of course, administrative and organizational problems, legislative codes, licensing, and such. There are specific techniques related to radiation protection itself which are important.

Suitable texts were mentioned. At one school in St. Louis, every medical student is expected to buy and to assimilate at least the first half of the text on "Radioactive Isotopes and Clinical Medicine" by Quimby, Feitelberg, and Silver. It is impressive that a school would require such a comprehensive coverage.

A discussion of the use of visual aids revealed interesting techniques. In a medical center, they put up an X-ray "Case of the Week"; at Tulane, they not only exhibit material on cases of medical interest but also show a film intermittently that illustrates radiation protection facets, such as shielding of the gonads when they might be included in the primary beam.

Space, staff, and money always come up. There was unanimity in the belief that, even though much is being done and very good programs have been organized, most of the better programs have been subsidized. Apparently they would have been impossible without subsidization. Those without subsidies agreed that their programs could and should be improved by some pertinently directed financial support.

Two points of great need were considered in more detail. One was improvement of training groups in the undergraduate medical school and the various specialties. Help is needed here in practically all schools, even the ones with good programs in other respects. Sums as little as $20,000 a year plus an initial grant of $25,000 to $50,000 for an original nonrecurring equipment fund, would do much and would be a significant contribution to all of the medical centers trying to improve their programs.

In the more selected institutions which might undertake something that would add to our group of radiological physicists and radiation health specialists at high level, and there are only some 15 centers that one could expect to undertake this more selective training, probably $200,000 to $300,000 a year would be needed for each of them, give or take $100,000 to supply both personnel fellowships and the subsidy required by the university for space and facilities.

Votes were not taken on these points. No motions were made. But there was, as I looked around, good agreement and no very strong dissent to considerations in this type of broad general opinion.

We considered the possibility of action programs in other ways. One suggestion was a symposium or teaching institute on this subject for medical educators, sponsored possibly by the Association of Medical Colleges.

There was also a very short discussion of the possibility of preparing an American counterpart, if you will, of the British report, as worthy of consideration but dealing with our own problems more specifically. This would be quite a large job if we tried to do it with the needed completeness.

In summary, it is our belief that the problems are complex but not insurmountable, that radiation health education is important, that it deserves more emphasis than has been given to it.

There was enthusiasm that much can be done; we are not stymied and we have ideas on what to do and how to do it. There was a unanimity of opinion, however, that we do need and can very well use some financial support.

Dr. James A. Crabtree: I am going to report first on the one aspect of this problem that was completely ignored in our discussion. Nobody alluded to it in any way whatever and I am going to report on it here by telling a story.

It seems there was a distinguished president of one of our older and most esteemed universities who, some years ago, was presiding over a faculty that was called to consider certain matters of educational policy. These matters were quite controversial and it wasn't long until the faculty was in a first class hassle. It became quite clear to the president that these issues could not be resolved. The discussions reached the pitch of great heat and little light, he pounded on the table, arose, and said, "Gentlemen, just before I adjourn the meeting, I would like to remind you that no system of education has yet been devised that will keep a good man down."

I think this is somewhat relevant to our discussion here. We need to consider the quality of students equally with techniques of curriculum. It is possible that the quality of students may well determine the character of the curriculum, whatever those of us who pontificate about this problem may decide.

At the outset, our section agreed that our discussion during this short day would focus on certain specific questions. The first of these was, "Does the School of Public Health have a significant role to play in the determination of educational needs in the field of radiation health?"

Several speakers, notably Dr. Weber and Dr. Morgan, in preparing the setting for this conference, emphasized the multidisciplinary and multiprofessional character of the problem. As our knowledge advances and is extended in depth concerning any phenomenon that has roots in science, the validity of the concept of independence lessens and the importance attached to interdependence is strengthened.

Certainly the concept of multifaceted etiology is the very warp and woof of public health and gives it its own special philosophy. If we strip any problem of its multidisciplinary and multiprofessional features, it loses its public health significance. In the modesty that is characteristic of schools of public health, we claim to be somewhat unique among our sister schools in the university, particularly among schools in the health sciences, in that we have learned especially to bring multidisciplines and multiprofessions into focus on a problem. We have learned and proved the competence to do so with some degree of success. Therefore, we conclude that we do have not only an important and significant role to play but, in some respects, a unique one in this multifaceted problem of radiation health.

We see the radiation health problem, however, as differing in no basic essential from any other environmental health problem. The approach to its solution differs in no way. In details, yes, but in basic essentials, no.

The traditional approach to a public health problem involves some understanding of the behavior of the agent or agents that contribute to health or the lack of it. It involves certain skills for effective application of knowledge toward the protection of human health on a community basis. These skills derive from an understanding of the processes of quantitation (statistics), the methodology of epidemiology, and the tools of organization and administration.

These are the "sine qua non" of the approach to a public health problem. The characteristics of the radiation health problem distinguishing it from many other public health problems is that our knowledge of the natural history, the behavior, and the impact of the agent (ionizing radiation) on human health derives from two relatively new and not generally understood disciplines, popularly known as radiation physics and radiation biology. The second characteristic is that our state of knowledge in these two fields is not yet sufficiently advanced or sufficiently systematized and organized or widely enough possessed to enable us to develop programs of application with the same competence that is possible in older and more traditional fields.

Yet this is by no means unique to radiation health in the public health picture today. Increasingly, the problems facing public health are emerging from disciplines in no better or even worse state of development than the radiation field.

We then addressed ourselves to the second question: "What categories of students can we best serve in the Schools of Public Health?"

Considering how few we are in this country, how unique our resources and, in these terms, how precious our assets, it was agreed that we should confine our contribution to graduate education.

It's true that some schools of public health have opportunities and do, in fact, engage in undergraduate teaching, but we agreed to hold our discussion for present purposes to graduate education. We thought it would be unfortunate if we tried to categorize the students that we should train purely in terms of their vocational objectives. Rather, we preferred to place our students in such categories as those aspiring to a career in public health with primary responsibility in the field of radiation health, and those whose normal responsibilities would be in areas where radiation health would be of only incidental interest. We didn't see any fundamental differences except in degree and depth; there is no fundamental difference in the character of their training.

We agreed further that our primary concern in the School of Public Health is the student who potentially would have primary responsibility and who aspires to become ultimately a radiation health specialist.

We concluded that, as a specialist in control of radiation hazards on a broad scale, our student could qualify only if, in addition to the mastery of a specific discipline he also had the skills traditionally fostered over the years in schools of public health. Normally such persons have backgrounds in medicine, engineering, biology, and chemistry.

It was agreed that many, if not all of them, could be expected to have one or more academic deficiencies whether the individual aspired to a master or a doctorate degree; that the program would be basically the same differing only in degree; that we had to give consideration to variations that are inherent in differences in faculty background as between different schools. If we try to delude ourselves that these differences in faculty background are not important, then our whole discussion here would be quite academic.

We did not attempt to spell out what the curriculum should be. We can state with confidence, however, that the curriculum should include radiation physics and radiation biology as required courses and I use these two terms in the broadest sense.

Exposure to what we regard as the core concept of public health—environmental hygiene, statistics, epidemiology, and the principles of organization and administration—should be required as well.

Electives to "round out" the formal education of the student would be left to the discretion of the faculty of the individual institution. We would emphasize the need for flexibility within the program and the importance of containing the instruction within the context of total environmental health.

Finally, the program should include field training.

Time required for such programs was agreed to be from a minimum of 1 year to a maximum of 3 years or more to satisfy the doctorate degree.

There was a second category of students that we considered important within schools of public health. This is those students in public health whose major preoccupation after leaving school would not be in radiation health but where radiation health would be a minor or incidental concern.

It was agreed as a matter of principle that all students of public health crossing the threshold of our schools should be prepared to deal with radiological health problems at their own working level and in the context of their normal responsibilities.

We believe that this goal can best be achieved, from the educational point of view, by integrating radiological health concepts into the general curriculum of the school, making them a part of functional subject areas rather than presenting them as a quite different, separate, or unique problem.

We also agreed that there are ample opportunities in schools of public health to meet this goal. Indeed, it is being done reasonably well in some of our schools, keeping in mind that the ideal of general public health education is to give the student competence in general principles and in methods of approach enabling him to move into any new area within the limits of his technical or professional background. Within these limits, the success of this integration process will depend very largely upon whether the school has one or more persons on its faculty whose major preoccupation is radiation health. To expect integration of radiation health into the general curriculum without this facet is not very realistic.

Parenthetically, it was agreed that whereas radiation health interests and concepts need to be infiltrated into the general curriculum of schools of public health, reciprocally the curricula in radiation health found in other schools concerned especially with health physics could be greatly strengthened if some public health could be infiltrated into them.

We made little headway on the question "What facilities are required beyond the existing resources in our schools to develop these programs and what the financial and other implications are?"

This question could not be answered with confidence because we had no warning that such a question would be raised. Nobody was prepared to discuss it definitively.

The point of view was expressed, and there was no dissent, that the greatest single deterrent to the further development of these programs in our schools of public health was lack of staff. The general consensus was that we should regard the radiation physicist and the radiation biologist as our core staff.

Finally, we addressed ourselves to the question, "Do we stop here?" Two points were revealed.

Because of the extreme and serious shortage of qualified people to teach, we would like to suggest that support and promotion of advanced programs of study be made under a policy that would enable some of our doctoral graduates to be channeled into educational institutions rather than as at present exclusively into industry; and it was the hope of our group that the Public Health Service might be able to develop a program of training in this field at least on a par with that of the Atomic Energy Commission, permitting comparable numbers of persons to be educated in a program characterized qualitatively in terms of public health and with all the implications of those terms.

Professor P. H. McGauhey: The engineers will yield to no one on the scope or the sheer enthusiasm with which we entered into this discussion.

Approximately 60 conferees participated in the meeting on curricula of Schools of Engineering, to consider an appropriate radiological health program within these educational elements of American colleges and universities.

It was decided that the subject of radiological health and engineering programs could be discussed more intelligently after the six scheduled speakers had made their formal presentations. The breakdown of discussion topics announced in the program was decided to be more appropriate to the medical profession than to engineering. The satellite disciplines of the medical profession may be differentiated by degree of participation in health protection and control as against research and teaching, but no such differentiation is possible in engineering because of necessity, education in radiological health begins after the baccalaureate degree.

Professor Kiker of the University of Florida pointed out that control of radiation hazards is essentially based on a team effort by groups composed of such diverse elements as physicians, physicists, and engineers. Of these, the importance of one can hardly be emphasized over another, according to Professor Kiker. Nevertheless, the sanitary engineer may well become the leader or administrator of an essential program for the protection of public health through the control of environmental pollution from radioactivity.

A program of graduate study in sanitary engineering toward this end, for students interested particularly in radiation was set forth in detail at both the master and the Ph.D. level by Professor Kiker, using as a model the current University of Florida program.

Professor Kilcawley called for recognition of the need for national leadership in solving the complex problems of environmental control. He also stressed the interdisciplinary nature of radiological problems and suggested an educational program having three facets:

1. Informing the public, especially its legislative representatives, concerning the magnitude and urgency of the problem as well as the need for enabling or clarifying legislation;

2. Establishing university centers with comprehensive programs and competent staffs for teaching, research, and service; and

3. Having a vigorous appeal in the

recruitment of students.

The program of Renssalaer Polytechnic Institute was described in detail, emphasizing the opportunity it offers for specialization to begin in undergraduate years.

The question of whether radiological control represents an entirely new field or merely involves the introduction of new complications into well-established environmental activities, was posed by Professor Kaufman. He cited sound evidence that health physics has made solid gains but suggested that only time will tell whether it represents an emerging new profession. He discussed the problem of radiological health in two aspects, the management of radiation at the source and the transport of radionuclides in the environment to man.

Like Professor Kiker, Professor Kaufman noted that a wide variety of disciplines are involved in radiological health and that neither one nor the other of these is particularly favored in terms of suitability to deal with the entire problem.

The responsibility of radiological health programs must, of necessity, fall into capable hands if the public is to be protected. Some of these hands may be, and should be, those of sanitary engineers and industrial hygiene engineers. Both of these groups, therefore, have a place in radiological health but they may not expect to preempt the field. It was noted by Professor Kaufman that control of radiological health problems is now passing in an orderly fashion from AEC to more traditional governmental agencies both at the national and the State levels.

As to the curricula best suited to fitting the sanitary engineer to fill his appropriate role in radiological health, Professor Kaufman saw no place for special courses at the undergraduate level. However, the new movement of basic science into undergraduate programs can be expected to strengthen the background of the undergraduate student and introduce him to fundamental concepts of radiological health.

At the master's level, the student is expected to develop a knowledge of radiological science in one or two specialized courses but no specialized curriculum as such can be recommended for the sanitary engineer by Professor Kaufman short of the Ph.D program. At that level, however, the student of environmental or sanitary engineering particularly interested in radiological health could well take a minor of some 12 to 18 credit hours in the field of radiological health and a similar minor in chemistry.

Professor Gloyna supported Professor Kaufman in general. He went on to spell out in detail the context and the scope of a course suited to engineering and other technical students at the master's level. He noted how this same course could be modified to fit it to students in medical sciences, public health, and other less mathematical disciplines.

He also noted that the high cost per student in setting up a laboratory for a single course or for but a few courses can deter university action unless outside financial assistance is available. Nevertheless, the University of Texas, which he represented, joined with others in the field in considering radiological health engineering as one of the specialty courses required in the general area of sanitary engineering.

Professor Granstrom reminded the group that a recent conference on sanitary engineering, held at Cambridge, Mass., has recommended radiological health as one of the core courses required of all sanitary engineers at the master of science level. He presented tables drawn from university and college catalogues which showed the range of course offerings available to engineers through schools of engineering, schools of public health, medicine, and arts and sciences in the United States.

He suggested that in the past a lack of knowledge of physical chemistry has been a major deficiency of engineers. Seminars and conferences were devices he proposed to reduce the cost of radiological health instruction and to increase the scope of the educational experience of graduate students.

Professor Silverman noted that the industrial hygiene engineer was concerned with X-ray, mining, and other radiation hazards long before events of 1943 which led ultimately to this conference.

He noted that this interest, of course, was concerned with occupations particularly, rather than with environments. He noted, to the alarm of some of us, that of the 270 fellowships in radiological health, 90 percent of the students are in four universities. He found no problem in integrating radiological health into a program of industrial hygiene engineering or in relating this program to nuclear engineering. Even though no specific curriculum is provided, he does have one in his own field. He reiterated that recruitment is a tough problem and that all programs in radiological health should be graduate specialities.

Discussion continued for more than 3-1/2 hours following the formal presentation of the papers.

There was general and immediate agreement that the problem of radiological health is interdisciplinary, that it transcends any one specialty area, and that it is not likely to be preempted by any single discipline.

Nevertheless, it was agreed that engineering can and should make significant contributions to radiological control. Dr. Cowan of the Brookhaven National Laboratory stressed that the engineering approach is important to the solution of radiological health. He noted the lack of field experience of students concerned with radiological control and explained briefly how AEC facilities could be used effectively in an educational program, despite the limited capabilities of all the agencies concerned.

Extensive discussion centered around the possibilities of significant education in radiological health at the undergraduate level. A few institutions in particular—Florida, Case, Rensselaer Polytechnic Institute, Oregon State, and some of the junior colleges—foresaw the possibility of an early and effective program in radiological health. The majority, however, considered radiological health primarily as a graduate specialty and by impressive majority passed a resolution stating that the basic sciences should be stressed in the undergraduate years but that instruction in radiological health should be confined to the graduate years.

Extensive discussion of the nature of a graduate program to that end and what it might be expected to accomplish was ultimately summarized in a second motion which declared that it is the conviction of this group (attending the Schools of Engineering meeting) that some degree of specialized education in the environmental area of radiological health engineering can be provided within the time requirements of a master's degree, permitting adequate preparation in management and control operations. Additional study for at least 1 year, or preferably to the doctorate level, is required of qualified, specialized personnel in radiological health engineering.

Because the group represented primarily the sanitary engineering field, in the broad environmental sense of the term, the resolution was intended to refer largely to the preparation of such engineers for their proper role in dealing with radiological health problems.

The group recognized, however, that the engineering schools have the potential and the duty to make contributions to the solution of radiological control problems beyond their strictly environmental aspects. Academic preparation for the control of the hazards of radioactivity in the environment, therefore, required that engineers understand the origin of radiation hazards and the ways these radiation hazards may be controlled at the source, as well as the fate of radioactive substances released in the environment.

A formal resolution recognizing this greater opportunity for service by the engineering schools was therefore adopted. The resolution further stated that the group recognizes that radiological safety involving sources of ionizing radiation may be best served by orienting the emphasis of the educational program to fit the individual and that engineering schools can contribute in such ways as in the design and operation of X-ray machines, reactors, and so forth for the control of ionizing radiation as well as through the control of natural environments.

As to the specific course content necessary to educate the engineer in any level, the group recognized that no across-the-board curriculum could be spelled out within the time available nor certainly in the framework of the diversity of opinion that was expressed. The background of each individual student, the program offerings of the particular institution and the good judgment of experienced faculty members will serve to govern in each case. However, sound basic preparation in physics, chemistry and biology oriented towards their radiological aspects were considered prerequisite to any graduate or specialized courses.

The context of such courses were typified by outlines presented by several of the speakers. All of this material is to appear as appendices to the proceedings of the meeting.

Formal recognition of the cost of educating personnel in engineering schools for participation in the solution to problems of radiological health was taken by the group by a motion calling attention to the needs of educational institutions.

As set forth by the motion that the group adopted, the needs, as we foresee them, include: Fellowships, paying students at a higher rate than at present and extending over longer periods of time, and long-term subsidies for the teaching personnel needed to establish and develop educational programs. The third need is the long-term financial support of specific research. The fourth is financial support for the provision of additional space. And fifth, there is a need for a systematized program of field and practical training for students and staff.

The specific sources of this financial assistance to the program of radiological health education were not suggested beyond a general recognition that the continued combined effort of the educational institutions themselves and interested outside agencies is going to be necessary to provide it.

In discussion:

Dr. Merril Eisenbud: There is one aspect about which I feel strongly and which I should like to discuss for the record.

While we have heard how each of the schools--medicine, public health, and engineering—can best make its contribution to this field, it should be emphasized that the greatest contribution can be made if we utilize the resources of a university as a whole. Perhaps the greatest impediment at the present time to the granting of advanced degrees in our field is what I would describe as the academic red tape which channels people into specializations for which perhaps their interdisciplinary background would counterindicate.

At New York University, we have developed a system by which, although the program is based in the medical school, the teaching is actually performed in three schools and the committee which decides whether or not an individual gets his doctoral degree contains representatives from three schools (see p. 117). This committee guides the student through the intricacies of the university procedural requirements, thereby making it possible for him to end up with the Ph.D. or Sc.D. even though he comes to us with the formal requirements which would qualify him for any single department.

There should be encouragement for all universities to devise systems by which departmental compartmentalization can be broken down. When we tap the resources of a university as a whole, so that all departments regardless of what school they happen to be in can contribute to the program, our teaching program will be greatly accelerated.

Dr. James A. Crabtree: May I say that I think it would be most unfortunate if the comments from any of the three summarizers were to be interpreted as the last speaker has indicated.

Certainly there was no intention on my part, in presenting what I thought were the elements of the student curriculum, to imply that the totality of that program was necessarily within the confines of the four walls that house our school. If that impression was carried in the record, I am glad it was mentioned because I don't think it was intended.

Dr. George R. Meneely: I hope that our recommendations pertaining to medical school curriculum content, include the recommendation that all medical students complete the Atomic Energy Commission requirements for formal training in isotopes. Currently, I think this is 30 hours of formal training.

Some practical clinical experience with radioisotopes, especially tracer applications, could be gained with profit by the students during the time they are in medical school. Most of us believe, however, that practical work with patients which is also a part of the qualification for human use of radioisotopes probably belongs in the internship, residency or fellowship experience.

I hope that any recommendations emanating from this meeting will retain considerable open-mindedness about areas among the medical specialties as to where responsibility for the various facets of this program should come to dwell. I do hope that we don't reach any formal recommendations as to the specific departments of the medical schools which should come to control instruction in radiological health. Some aspects of this training belong properly in pre-clinical departments, some in several of the clinical departments. Cooperation across departmental lines is of the utmost importance in developing worthwhile training and work in this field. I agree with Dr. Chamberlain's expression that confidence and good will are the most important.

My final thought is that we should recognize that there is a good deal of diversity in the administrative organization of universities but the normal channel for master's degrees and for Ph.D. degrees is the Graduate School. Cognizance should be taken of this. I recommend personally, and I believe my school would back me up, that recommendation for legislation, formulation of regulations, statements of policy, and developments of program carefully include the eligibility of Graduate Schools for participation in such programs.

I concur with Dr. Eisenbud. The organization of our school is perhaps not very different from others (see p. 129). A number of department heads in the medical school wear two hats; they may be, Professor of Physiology and Chairman of the Department of Physiology for the School of Medicine, and also Professor and Chairman of the Department of Physiology for the Graduate School. It is important to recognize that there are two different entities for administrative purposes. For example, a grant to a Graduate Department channels through the Dean of the Graduate School, a grant to a Medical Department channels through the Dean of the Medical School.

Dr. Werner N. Grune; I would like to direct a question to Dr. Weber or the Public Health Service in general: How can the university and the Service best accomplish a recruitment program most effectively, or how can each one do their job best?

Dr. Francis J. Weber: The things we need to do in a program of recruitment are: (1) delineate rather clearly the fields in which we want to train specialists; (2) ascertain who has the proper background for training in each special field; and (3) determine the various sources of support and how such can be obtained in those areas short of support.

During some of the conferences I have attended, I heard the point emphasized that student stipends are a necessity in this competitive market for scientific talent; without such the institutions fare poorly in terms of sufficient student body. With them, they appear to do well, as Dr. Stannard stated yesterday. In contrast, Columbia has experienced difficulty, in spite of having a good course, because of lack of stipend resources. Dr. Gross mentioned the fact that tuition in the amount of $1,000 is required for admission there. At Rochester, Dr. Stannard is not experiencing the same difficulty in securing well-qualified applicants, because a majority of his students are receiving stipend support.

Certain practical logistic problems of this type, which do not involve large sums, interfere with the yield of candidates in a recruitment program. As a point in favor of student support is the fact that people trained in this field can hardly hang out signs somewhere as some professionals can when they complete their work, and subsequently recapture some of their educational investment via private activities. Most of them engage in teaching or research or become full-time institutional staff members in public health organizations or in such agencies as the Atomic Energy Commission. A regular salary in interesting work is the most that a majority can expect.

One could legitimately argue, it seems to me, that since any investment in stipends is comparatively small and, furthermore, since the graduates will make a proportionately greater contribution to the communities they will serve, it should be an investment which will pay off, speaking in strict economic terms.

I do not feel that successful recruitment will prove so difficult once the program is organized with reasonable resources made available. Suitable publicity will need to be given to it, including discussions held through the usual channels.

There are at least three representatives present from the Atomic Energy Commission, who have had practical experience in recruitment for some years--Dr. Claus is here, and Mr. G. W. Morgan, and Mr. Clare Palmiter. May we hear from Dr. Claus regarding his experience and that of his associates?

Dr. Walter Claus: The best way to recruit people for this program is to make salaries available for public health people, and others who are involved in the field, comparable to those available in industry.

We have had the experience of raising stipends for our fellowship program without in the least bit either increasing the number of applicants or in persuading people to accept the fellowship even after they had applied for it and had been awarded a fellowship.

So we're still subject to the play of the market place. But I don't know what the means might be for increasing salaries for people who are working in this field.

I must admit that when I first heard about this conference, I accepted an invitation to attend with some trepidation. I was a little worried that the group might be overpowered by the so-called "terrors" of radiation, by the "vast numbers of policemen" needed to keep it under control. I have been particularly impressed by the restraint with which the group has treated the problem and the manner in which it has recommended incorporation of training programs into existing programs. Dr. Weber and his associates have performed a very real service to the profession of radiation health protection in holding this meeting and getting the recommendations that have come out of it. I hope that you will be able to put a good number of them into effect.

Adjournment was announced by the chairman.

A Summation

General Conclusions:

It was agreed that radiological health specialist training should be at the graduate level and that this level of training is best accomplished in an institute of learning with an interdisciplinary faculty.

Concern was expressed that immediate quantitative needs might jeopardize quality in training specialists.

There was general concurrence that radiological health competency should supplement but not supplant training in industrial hygiene, public health, sanitary engineering, and other basic disciplines.

Little desire was expressed for so-called "standardized curricula" for specialists at this time, the infancy of programs and the need to match the interest of individuals being cited as reasons for maintaining flexibility.

The acute shortage of specialists was recognized generally. Information is lacking on definitive job assignments and lower salary levels result, as compared with other positions in nuclear energy usage. Universities face a minor but nonetheless real problem in space, facilities, and equipment; procurement of sufficient teaching staff is a fairly common obstacle; and a major problem is the lack of promising students.

It was acknowledged that to meet the need for specialists, particularly in public health agencies, support to universities and to students would be necessary, at about the same level as the AEC health physics program.

Integration of radiological health into the general curriculum is lacking or insufficient in most cases, it was agreed. It was further agreed that successful programs are most likely to result in those schools with specialist training objectives.

Already overcrowded curricula precludes the possibility of the introduction into undergraduate engineering or medical curricula of any new course pertaining specifically to radiological health.

In acknowledgment of the need for technician support personnel in the radiological health field, there was general concurrence that both short course training and 2-year college programs could serve in this role.

Additional short course training could also provide orientation or refresher type training to professional personnel.

Conclusions on Schools of Medicine:

Physicians who serve as administrators in full-time radiological health programs lose their entity in clinical medicine. But there is a need for physicians with graduate training in radiology, radiobiology, nuclear medicine, and other nuclear specialties in radiological health programs.

It was stated that medical schools by training graduate physics students can produce specialists as well as facilitate integration of radiological health into medical school curricula. The department of radiology was cited as assuming a primary role in such training.

Integrated training was considered of utmost importance. Medical interest in X-ray and wartime nuclear hazards and the need for an evaluation by a physician of risk versus benefit when radiation is used in therapy were cited.

Additional emphasis should be given to physics in the undergraduate program, more training should be given in nuclear physics, radiation, radiobiology, radiation effects, epidemiology, and more practical experience should be made possible with isotopes, X-rays, and protection techniques. This training varies at present from near 0 to 100 hours, according to the school.

With each school reporting a well integrated program, a major problem is found in attempts to convince the "Preclinical Committee" that there is a need to introduce training in radiological health.

Conclusion on Schools of Engineering:

It was resolved that adequate preparation could be given at the level of a master's degree to qualify persons for management and control positions in the environmental aspects of radiological health.

Apart from environmental control, engineering schools can contribute by supplying training in control of radiation sources, such as reactors and X-ray machines.

Study beyond the master's degree level, preferably to the doctorate but at least for 1 year, was recommended for the specialist in radiological health engineering.

Motions were considered and adopted on the needs of educational institutions in implementing these programs on a broad scale, as follows:

1. Fellowships which pay students at a higher than current rate, for longer periods of time, at least for more than 1 year.
2. Long-term subsidies for educators, to establish and develop training programs.
3. Long-term support of specific research.
4. Financial aid in supplying adequate facility space.
5. Systematized program of field and practical training for present staffs.

It was reaffirmed that a general course in radiological health should be included in graduate sanitary engineering curricula leading to the master's degree, because of the potential involvement of every phase of sanitary engineering with radiation hazards. (The recent ASEIB conference on sanitary engineering curriculum made a similar recommendation.)

The general radiological health course introduced into the graduate curricula was tacitly assumed to be a 3-semester-hour course, incorporating the fundamentals of radioactivity and radiation, environmental surveillance, and waste disposal. A deterrent to the introduction of such courses is the cost of instrumentation, estimated at about $50,000.

The need for cooperation among the various schools in a university complex was stressed, particularly in sanitary and nuclear engineering. Sanitary engineers can assist in integrating radiological health courses into the nuclear engineering field.

Conclusions on Schools of Public Health:

Schools of Public Health, being based on a multidisciplined approach to the teaching of public health subjects, appear particularly adapted to training of radiological health specialists and have a unique responsibility and role for such training.

Although currently there is considerable variance in the content at the master's level training at the several schools conducting specialist training, there was agreement that these programs should include:

1. Radiation health, with emphasis on physics and biology.
2. Public health core courses, such as environmental hygiene, statistics, epidemiology, and administration.
3. Electives, to permit flexibility. . .
4. Field training for a minimum of 10 weeks.

Certain schools have adopted a 1-year curriculum for the health physics fellowship program which omits many of the public health core courses. Although it could be assumed that a 2-year program (or perhaps 1-year on a trimester system) would be preferable for specialist training at the master's level, there was no group recommendation on this point.

Among factors impeding the strengthening of specialist training, facility and equipment needs were considered, but the shortage of teaching staff was apparently most critical. It was recommended that additional doctoral candidates who potentially could serve as university staff be given support.

There was total agreement that all students majoring in public health should have indoctrination training in radiological health.

Although a one-semester radiological health course is offered in several schools, the majority devote a portion of several courses to this topic. At a minimum, 8 hours on radiological health should be incorporated into the core course on environmental sanitation. In addition, various aspects of the problem should be introduced into virtually all courses offered.

It was acknowledged that the amount of radiation training given at various schools would vary significantly and that the degree of success will depend principally on faculty with a major preoccupation in radiological health.

Another "stop-gap" approach which has been used successfully at two of the schools is to conduct a 2- or 3-day radiological health seminar for all public health students.

Radiological Health Curricula Inventory

This inventory is based mainly on information provided by university staff attending the Princeton Symposium on University Curricula in Radiological Health (1960). Certain data were extracted from university catalogs and other publications. Recognizing that the material presented is incomplete and subject to change, requests for further information regarding a specific university program should be directed to the individual designated in this listing. To enable periodic up-dating of the inventory, notice of changes or additions to this listing should be sent to the Chief, Division of Radiological Health, U. S. Public Health Service.

1. UNIVERSITY OF CALIFORNIA AT BERKELEY

a. Department of Engineering - P. H. McGauhey, Chairman, Div. of Hydraulic and Sanitary Engineering

Curriculum Title: Sanitary Engineering with Major in Radiological Science (Ph.D. only)

Group I Courses
- Intro. to Atomic Structure
- Nuclear Chemistry
- Physical Chemistry
- Environmental Physiology

Group II Courses
- Rad. Aspects of Pub. Health Engr.
- Biol. Effects of Radiation
- Artif. Radioactivity in the Biological Sciences
- Nuclear Physics in Biology
- Physics of Biol. System
- Health Physics - Instrumentation

A student entering this program with a B.S. degree must first complete minimal core requirements for M.S. in Sanitary Engineering, but may also begin course work leading to Ph.D.-level major in Radiological Sciences.

b. School of Public Health - Charles E. Smith, M.D., Dean

Curriculum Title: Radiological Sciences Curriculum leading to M.S. and Ph.D. Degrees (Proposed Program)

This curriculum will include a two-semester M.S. program and a more extensive Ph.D. program. The common core courses will emphasize radiological source management and environmental control of radiation.

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2. CALIFORNIA INSTITUTE OF TECHNOLOGY

Division of Engineering - J. E. McKee, Professor of Engineering in Environmental Health

Curriculum Title: Environmental Health Engineering Program

Courses offered in Radiological Health area:

Biophysics
Radioactivity & Isotopes
Radioisotopes Laboratory
Nuclear Physics

A core program leading to an advanced degree in radiological sciences is not currently being offered. Students registered in one of the Science or Engineering Divisions may enroll in elective courses pertaining to nuclear energy and radiation health.

3. UNIVERSITY OF CHICAGO

Division of Biological Science - Lowell Coggeshall, M.D., Dean

A study core leading to a major or a degree in radiological science is not currently being offered. The M.S. and Ph.D. degrees are offered in Pharmacology and Biophysics and tailored to the student's abilities and needs.

4. UNIVERSITY OF CINCINNATI

a. School of Medicine - Dr. Eugene L. Saenger, Assoc. Professor, Radiology Dept.

Two courses in radiobiology are offered.

b. College of Medicine, The Kettering Laboratory - Dr. Herman Cember, Assoc. Professor of Industrial Health

Three courses in health physics are taught as part of the training program for industrial hygienists and industrial physicians. Research opportunities are available in health physics.

5. COLUMBIA UNIVERSITY

College of Physicians and Surgeons - H. H. Rossi, M.D., Professor of Radiology

Curriculum Title: Program Leading to a Master's Degree in Radiological Physics

Courses offered:

- Basic Radiological Physics
- Adv. Radiological Physics
- Electronics
- Standardization and Protection
- Special Topics in Medical Physics
- Radiobiology
- Clinical Applications of Radiological Physics
- Clinical Uses of Radioisotopes
- Biostatistics
- Integrated Lab Course
- Seminar

6. CORNELL UNIVERSITY

Department of Sanitary Engineering - Charles D. Gates, Chairman

A major curriculum is not presently being offered in radiological science. The student majoring in sanitary engineering would pursue course work in radiological health, radioactivity measurements, and radioactive wastes and could choose a thesis dealing with radioactivity in water, wastes, or related subjects.

7. UNIVERSITY OF FLORIDA

a. College of Medicine - John D. Reeves, M.D., Head Professor of Radiology

Medical and Radiation Physics and Radiological Health Programs (Proposed): Graduate program and cooperative courses planned under Division of Radiological Physics and Department of Radiology

b. School of Engineering - John E. Kiker, Jr., Professor of Civil Engineering

Curriculum Title: Radiation Hygiene and Hazard Control (Sanitary Engineering)

Core Courses for Master's Degree:

- Quantitative Analysis
- Physical Chemistry
- Intro. to Nuclear Engr.
- Problems of Nuclear Radiation in Environmental Sanitation
- Stream Sanitation
- Atmospheric Pollution

Core Courses for Ph.D. Degree:

- Physical Chemistry
- Nuclear Chemistry
- Water Supply & Treatment
- Evaluation of Engr. Data
- Adv. Public Health Engr.
- Microbiology of Waste Treat. and Receiving Waters
- Micrometeorology of Pollutant Dispersion
- Radiation Effects & Radiation Biology

8. HARVARD UNIVERSITY

School of Public Health - Prof. Leslie Silverman, Director, Radiological Hygiene Program and Prof. of Engr. in Environmental Hygiene

Curriculum Title: Radiological Hygiene - M.S.

Core Courses:
- Radiological Hygiene
- Chem. of Nuclear Materials
- Human Physiology
- Industrial Air Analysis
- Biostatistics & Epidemiology
- Advanced Radiological Hygiene
- Radiological Engineering
- Toxicology & Radiobiology
- Aerosol Technology

Students may register for a degree through the Graduate School of Arts and Sciences with a B.S. in Engineering or Physical Science or through the School of Public Health with one year of previous graduate work.

9. UNIVERSITY OF ILLINOIS

School of Engineering - Ben B. Ewing, Assoc. Professor of Sanitary Engineering

A M.S. degree can be taken in either Sanitary Engineering or Nuclear Engineering using one as the major and the other as a minor.

10. JEFFERSON MEDICAL COLLEGE AND HOSPITAL

Department of Radiology - Dr. P. J. Hodes, Professor of Radiology

Curriculum Title: Radiological Physics

Courses offered:
- X-ray physics and radiation protection
- Radioisotope handling and measurement techniques
- Radioisotope Physics
- Fundamentals of Radiation Biology

A three-year traineeship program is offered including formal course work and on-the-job training to prepare candidate for certification exams in radiological physics by the American Board of Radiology.

JOHNS HOPKINS UNIVERSITY

School of Hygiene and Public Health - Russell H. Morgan, M.D., Professor, Division of Radiological Science & Chairman, Dept. of Environ. Medicine

Curriculum Title: Radiological Health

Courses:
- Radiobiology
- Radiation Physics and Dosimetry
- Radiochemistry
- Radiation Protection
- Physical Chemistry
- Biology
- Adminis. of Radiation Control Programs
- Clinical Radioisotope Application
- Clinical Radiation Therapy
- Special Studies and Research
- Intro. to Physics
- Analytical Geometry & Calculus

Students are chosen from applicants who have a M.D. degree, or a B.S., M.S. or Doctor's degree in the Physical Sciences, Biological Sciences or Engineering and who will be candidates for the Sc.M., Sc.D., M.P.H. or Dr.P.H. degree. Candidates take the basic course work offered by the School of Hygiene & Public Health for a Master's degree in Public Health which includes courses in pathobiology, biostatistics, public health administration, epidemiology and sanitary engineering. A part of the student's time is available for research which may be undertaken either at the basic science level or in one of the applied fields. Research opportunities are available in the clinical areas of radiation therapy, radioisotope application and roentgen diagnosis for those students with a M.D. degree.

12. UNIVERSITY OF KANSAS

Radiation Biophysics Committee - Frank E. Hoecker, Chairman & Prof. of Physics & Radiation Biophysics

Curriculum Title: Radiation Biophysics

Core Courses:
- Intro. Radiation Biophysics
- Radiation Protection
- Radiation Dosimetry and Shielding
- Basic Radiation Biology
- Radiological Techniques
- X-ray & Gamma Ray Measurements
- Problems in Biophysics
- Radiological Physics
- Radiation Biophysics Seminar
- Special Topics in Radiation Biology
- Clinical Application of Radioactive Isotopes
- Radiation Biophysics Thesis
- Radiation Biophysics Research

Additional courses which may be selected or substituted by qualified students:
- Electric circuits
- Vacuum-tube Electronics
- Nuclear Physics
- Mammalian Physiology
- Introductory Biochemistry
- Elementary Physical Chemistry

13. MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Sanitary Engineering Division - Prof. Rolf Eliassen, Head

Curriculum Title: Sanitary Engineering

Core Courses for M.S. & Ph.D.:
- Intro. to Nuclear Technology
- Biol. Effects of Nuclear Rad.
- Nuclear Wastes Disposal
- Sanitary Engr. Courses
- Research

Courses for Ph.D.:
- Atomic & Nuclear Physics
- Biochemistry & Physiology

14. UNIVERSITY OF MICHIGAN

School of Public Health - William Gibson, Acting Dean

Curriculum Title: Radiological Health

Basic Courses in Radiological Health (Suggested for A.E.C. Fellows in Health Physics)

Statistical Methods in Public Health
Principles & Methods of Occupational Health
Intro. to Nuclear Engr.
Measurement in Nuclear Engr.
Field Work in Radiological Health
Radiation Biology
Radiological Health Seminar (I & II)
Radiological Health

In addition to the above, the following courses are required of environmental health students in the radiological health program:

Pub. Health Administration and Law
Prin. of Epidemiology
Prin. of Envir. Health
Environmental Health Seminar
Tech. Used in Radioactive Air, Water, Sewage, & Stream Pollution Studies
Disposal of Radioactive Wastes

Students with adequate experience and academic background may complete a program in environmental health satisfying the requirements for the M.P.H. degree in two semesters. Students with acceptable academic backgrounds for the environmental sequences but lacking the requisite three years of experience in public health are required to pursue two academic years of study to fulfill the requirements of the M.P.H. degree.

15. MICHIGAN STATE UNIVERSITY

Civil & Sanitary Engineering Dept. - John Hoffman, Director of Engineering Research

Curriculum Title: M.S. Degree Program in Sanitary Engineering

Courses offered:

- Radiological Health
- Air Pollution
- Radio-Chemistry

A graduate program in Radiological Health is currently being planned on an interdepartmental basis - Sanitary Engineering, Nuclear Engineering, Physics, Chemistry and Physiology.

16. UNIVERSITY OF MINNESOTA

School of Public Health - Gaylord W. Anderson, M.D., Director

Curriculum Title: Environmental Health

Courses offered with emphasis in Radiological Health:

- Control of Rad. Hazards
- Topics: Rad. Health Projects
- Biometric Prin. & Lab
- Environ. Sanitation
- Industrial Hygiene Engr.
- Nuclear Reactor Design
- Exper. Nuclear Physics

Programs of study leading to the M.P.H. degree are available in the School of Public Health. The Graduate School of the University provides programs leading to degrees of M.S. and Ph.D. with Environmental Sanitation -- in this latter case the School of Public Health serves as a department of the Graduate School.

1) The M.P.H. degree is open to properly qualified persons with either one year of graduate work in a field related to public health or with three years experience in the public health field.

2) The M.S. degree with a major in Environmental Sanitation does not require prior graduate study or public health experience. Candidates must have a Bachelor's degree in engineering or a Bachelor's degree with major work in physical or biological sciences.

17. NEW YORK UNIVERSITY

Institute of Industrial Medicine - Merril Eisenbud, Professor

Curriculum Title: Radiological Health

Courses offered:

- Intro. to Rad. Health
- Radiological Safety Lab.
- Adv. Radiological Health
- Rad. Hygiene Measurements
- Biol. Effects of Radiation
- Radiochemical Analysis
- Nuclear Engineering
- Industrial Hygiene
- Ind. Hygiene Lab.
- Intro. to Statistics
- Research in Rad. Health
- Environ. Radiation

1) Master's program - Qualified students with the B.S. or equivalent will be accepted with considerable latitude permitted as to the scope of undergraduate training, especially if candidate has had practical experience in radiological or industrial hygiene.

2) Ph.D. Program - Particular encouragement given to engineers, physicists, chemists, or biologists, who have completed the requirements for the master's degree and who have had several years of practical experience in which they have demonstrated a capacity to undertake advanced field assignments.

18. UNIVERSITY OF NORTH CAROLINA

School of Public Health - Prof. Emil T. Chanlett, Professor of Sanitary Engineering

Graduate courses offered in Radiological Science:

Radioactivity in Air, Food & Water
Radiochemistry
Lab. Techniques in Radiochemistry

The curriculum for a major or degree in radiological science is not currently being offered, but resources have been reviewed for development of a program of radiological health instruction with support from the nuclear physics engineering staff and facilities of North Carolina State College.

19. NORTH CAROLINA STATE COLLEGE

A curriculum leading to a degree in radiological health is not currently being offered. Relevant courses offered in the certain Departments are indicated below.

a. School of Engineering - C. Smallwood, Jr., Professor

Radiation Hazards & Protection
Radioactive Waste Disposal
Evaluation of Radiation Hazards

b. Zoology Department - Frederick Barkalow, Jr., Head

Biological Effects of Radiation

c. Chemistry Department - Alonzo F. Coots, Assoc. Professor

Radioisotope Principles
Radioisotope Techniques

20. UNIVERSITY OF OKLAHOMA

Sanitary Science Department - Prof. George W. Reid

Curriculum Title: M.S. in Sanitary Science & Ph.D. in Engineering Science

Core Courses:

- Radioisotope Techniques
- Industrial Hygiene & Safety
- Industrial Sanitation
- Environmental Sanitation
- Sanitary Chemistry
- Industrial Wastes
- Milk & Food
- Toxicology
- Atomic Physics
- Radiochemistry
- Radiobiology
- Statistics
- (Other Physics courses)
- (Nuclear Engr. courses)

Those students majoring in the sanitary science program take at least 5 of the courses listed above. The basic core courses occupy 1/3 to 1/2 of the student's time, with the remainder of the work spent in the field of specialty (e.g., radiological health, sanitary engineering, chemistry, biology). The Ph.D. program requires 60 hours beyond the Master's including the thesis.

21. OREGON STATE COLLEGE

School of Science - John R. Prince, Radiation Safety Officer

Lecture courses in radiobiology are currently offered, with future plans to expand this program and start a supporting research program.

22. UNIVERSITY OF PITTSBURGH

Graduate School of Public Health - James A. Crabtree, M.D., Dean

Curriculum Title: Radiation Health

Radiation Health Program Courses:

- Health Physics & Health Physics Lab.
- Prin. of Stat. Reasoning
- Intro. to Occup. Health
- Man & Environment
- Prin. of Pub. Hlth. Practice
- Prin. of Epidemiology
- Environmental Physiology
- Industrial Hygiene
- Radiobiology
- Public Health Seminar
- Health Physics Seminar
- Research & Thesis for Master's Degree
- Special Studies
- Reactor Hazards

The graduate study program is planned to lead to a Master of Public Health or a Master of Science in Hygiene degree. Advanced training leads to the Doctor of Science in Hygiene, the Doctor of Public Health or Ph.D.

The two-year program provides 60% of the student's time in didactic work, with the remainder of the time to be spent in clinical, field, or research work related to the student's interests. The doctoral candidates will be given additional clinical and field work.

23. RENSSELAER POLYTECHNIC INSTITUTE

Division of Environmental Engineering - Prof. E. J. Kilcawley, Head

Curriculum Title: M.S. in Environmental Engineering

Radiological Health courses:

- Atomic & Nuclear Physics
- Radiation Biology
- Radiochemistry
- Instrumental Analysis

Plans are under way for extension of curricula to include courses in monitoring, disasters, biological hazards and reactor control.

24. UNIVERSITY OF ROCHESTER

School of Medicine and Dentistry - Dr. J. N. Stannard, Assoc. Dean for Graduate Studies

Curriculum Title: Radiation Biology - M.S. & Ph.D.

Two plans are available for the M.S.: Plan A - research required (primarily for research and teaching professions); Plan B - without research but with comprehensive exam and essay (largely for radiation protection field). Ph.D. in Rad. Biol. uses the M.S. first year as a base.

Courses in Health Physics Program - M.S.:

Rad. Physics	(5 hrs.)	Electives	(2-3 hrs.)
Electronics	(3-6 hrs.)	Biol. Eff. of Rad.	(3-6 hrs.)
Statistics	(3-6 hrs.)	Toxicology	(2 hrs.)
Eval. of Rad. Hazards	(2-3 hrs.)	Ind. Hygiene	(3 hrs.)
		Health Physics	(5 hrs.)

Summer at Brookhaven National Laboratory

Courses in DASA* Program for Medical Officers:

Rad. Physics	(3 hrs.)	Toxicology	(2 hrs.)
Statistics	(3 hrs.)	Ind. Hygiene	(3 hrs.)
Eval. of Rad. Hazards	(3 hrs.)	Health Physics	(2 hrs.)
Ind. Medicine	(4 4 hrs.)	Biol. Effects of Radiation	(6 hrs.)

Informal Seminars

Summer at Idaho Falls, Nevada Test Site, Sandia, Bethesda, and Walter Reed.

*Defense Atomic Support Agency

Typical Program for Ph.D. in Radiation Biology:

First Year

Atomic & Nuclear Physics	(0-6 hrs.)	Health Physics	(0-3 hrs.)
Rad. Physics	(3-5 hrs.)	Ind. Hygiene & Toxicology	(5 hrs.)
Statistics	(3-6 hrs.)	Biol. Effects of Radiation	(3-8 hrs.)

Subsequent Years

Physiology	(8 hrs.)	Cellular Phys.	(0-3 hrs.)
Biochemistry	(8 hrs.)	Phys. Chemistry	(0-6 hrs.)
Pharmacology	(0-6 hrs.)	Genetics	(0-6 hrs.)

Specialty Seminars	(10-20 hrs.)
Electives	(10-20 hrs.)
Research	(40-60 hrs.)

Curriculum Title: Biophysics

Typical Ph.D. Program in Biophysics:

Quantum & Atomic Physics	(6 hrs.)
Quantum Mechanics	(3-9 hrs.)

24. UNIVERSITY OF ROCHESTER—Continued

Typical Ph.D. Program in Biophysics: (Continued)

Methods of Theoretical Physics) or) Modern Physics Laboratory)	(6 hrs.)
Organic Chemistry	(8 hrs.)
Physical Chemistry	(4-8 hrs.)
Mathematics	(3-9 hrs.)
Physiology	(8 hrs.)
Biochemistry	(8 hrs.)
Radiation Biology	(0-6 hrs.)
Other Preclinical Subjects	(0-9 hrs.)
Seminars	(8-10 hrs.)
Research	(30-50 hrs.)

25. ST. LOUIS UNIVERSITY

School of Medicine - Dr. George E. Thoma, Head, Section of Nuclear Medicine

Curriculum Title: Radiological Health

Program for training Radiological Health Specialists (Proposed):

The radiological health curriculum would include the following courses:

- Radiobiology
- Health Applications of Radioisotopes and X-rays
- Biostatistics
- Health Problems Associated with Nuclear Technology
- Epidemiology
- Radiation Protection
- Environmental Hygiene
- The Organization & Administration of Health Programs

This program would require a bachelor's degree in physics, chemistry, engineering, or in the life sciences. The curriculum in radiological health would fulfill the requirements for a master's degree in their fundamental discipline. A major in physical science would require work equivalent to a minor in biology, and a major in the life sciences would require work equivalent to a minor in physics and mathematics.

In addition to the course work, time would be spent participating with the Section of Nuclear Medicine in the various phases of clinical and nuclear medicine.

A nine-week postgraduate course in the Medical Aspects of Radiological Health was given by the Section of Nuclear Medicine with the support and assistance of the Division of Radiological Health of the Public Health Service. The broad course outline of topics covered is as follows:

- Review of Math & Basic Physics
- Radiation Physics
- Sources of Rad. Exposure
- Radiobiology
- Analysis of Rad. Hazards
- Radiation Protection
- Administrative Control
- Appl. of Radioisotopes

A postdoctoral training program in Nuclear Medicine is offered to provide training to the physician in subhuman and human radiobiology, radiation health, and investigative and clinical applications of nuclear energy. It is designed to provide the physician with an opportunity to conduct supervised research in nuclear medicine, or research in other phases of medicine utilizing the techniques of nuclear medicine.

The didactic portion of the program includes courses in the following areas:

- Mathematics
- Physics
- Health Physics & Radiation Protection
- Radiobiology
- Clinical Uses of Radioisotopes
- Research Techniques

26. UNIVERSITY OF TEXAS

School of Engineering - Earnest F. Gloyna, Prof. of Civil Engineering

Curriculum Title: Sanitary Engineering

M.S. Degree Courses:
- 9 hrs. Grad. San. Engr.
- 3 hrs. Grad. Rad. Health
- 3 hrs. Radiochemistry
- 3 hrs. Modern Physics
- 6 hrs. Thesis in Related Area
- 6 hrs. Elective in Radiobiology, Nuclear Engr., and Physics

Ph.D. Degree Courses:
- 1st Minor - 18 hours:
  - Physics
  - Biology
  - Chemistry
  - Bacteriology
- 2nd Minor - 9 to 12 hours:
  - Nuclear Engr. or other area

A course in Radiological Health is also given for physicians.

27. UNIVERSITY OF TORONTO

School of Hygiene - Dr. A. J. Rhodes, Dir. of School of Hygiene

Radiological health topics are incorporated in various courses offered. Specialized courses include an elementary course in radiation biology, a refresher course in "Radioisotopes" lasting 2 weeks, and a lecture course in "The Biological Effects of Radiation" of 36 hours over one academic year.

28. VANDERBILT UNIVERSITY

a. School of Medicine - George R. Meneely, M.D., Assoc. Professor of Medicine

Curriculum Title: Biophysics

Among the courses offered:

- Use of radioactive tracers in metabolism
- Microbial biophysics
- Radiochemistry
- Medical statistics
- Statistical methods for research in the medical fields

72 semester hours are required in physics, math, biology, biophysics (and other fields) of which 24 hours will be in thesis research.

b. Graduate School - Robert T. Lageman, Ph.D., Prof. of Physics

Curriculum Title: Health Physics - M.S. (Dept. of Physics)

Core courses:

- Electric Circuits
- Atomic & Nuclear Physics
- Elec. & Magnetic Field
- Adv. Physics Lab.
- Applied Radiation Physics Seminar
- General Biology
- Special Problems in Rad. Biology

The following courses are elective:

- Atomic Spectro
- Intro. to Theor. Physics
- Quantum Mechanics
- Electronics
- Adv. Calculus
- Math. Theory of Statistics
- Theory of Functions of a Complex Variable
- Adv. Differential Equations
- Radiochemistry

The curriculum requires 24 semester hours in physics, math and radiobiology plus a thesis.

Physicians may pursue a curriculum leading to a Master's degree in Health Physics or Biophysics with emphasis in radiobiology or studies may be planned to fit the particular needs of any individual.

Clinical training is available in radiobiology including: routine clinical medical methods; advanced scintillation and low level work; and research-training within the instrumental capabilities of the Graduate School and the Medical School.

29. MEDICAL COLLEGE OF VIRGINIA

Dept. of Biophysics & Biometry - Prof. William T. Ham, Jr., Chairman

Curriculum Title: Biophysics, Biometry and/or Radiobiology leading to Ph.D. degree

Typical Curriculum:

Physical Chemistry
Theor. & Math. Statistics
Biochemistry
Physical Chemistry

Physiology
Adv. Radiobiology
Thesis (Radiobiology)

Applicants for advanced training in Radiobiology should have a M.S. or its equivalent in health physics.

30. UNIVERSITY OF WASHINGTON

Radiological Science Group - Ralph M. Baltzo, Coordinator of Radiological Science (The Radiological Science Group includes the Graduate School, the Medical School, and the Engineering School).

Curriculum Title: Health Physics

Courses offered:

Phys. Lectures	(6 hrs.)	Cont. of Radioactive Waste	(4 hrs.)
Physics Labs	(9 hrs.)	Biol. Tracer Techniques	(2 hrs.)
Exp. Dosimetry	(2 hrs.)	Rad. Instruments	(3 hrs.)
Theor. Dosimetry	(4 hrs.)	Indust. Hygiene Tech.	(3 hrs.)
Rad. Biology	(3 hrs.)	Air Pollution Control	(3 hrs.)
Human Genetics	(3 hrs.)	Biostatistics	(3 hrs.)

Radiochemistry	(5 hrs.)
Reactor Theory	(5 hrs.)
Seminar	(2 hrs.)
Thesis	

NOTE: Radiological health curricula of Emory University, the University of Iowa, and Rutgers University were not available to the editors when this publication went to press. Requests for this data should be directed to the symposium participants from the three universities.

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